THE FEBRUARY SCIENTIFIC MONTHLY

EDITED BY J. MCKEEN CATTELL

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THE SCIENTIFIC MONTHLY

FEBRUARY, 1935

THE SURFACE FEATURES OF THE MOON[1]

By F. E. WRIGHT

GEOPHYSICAL LABORATORY, CARNEGIE INSTITUTION OF WASHINGTON

THE moon needs no introduction. It has been known to all of us from early childhood when we first tried to reach out and touch it and later learned to decipher both the man and the lady in the moon. In spite of this general interest and friendly feeling toward the moon, the president of the Carnegie Institution of Washington realized several years ago that its presence in the night sky is resented by the modern astronomer, especially the astrophysicist. Its light interferes with the photography and analysis of far distant, faint celestial objects, such as stars, clusters and nebulæ—incandescent masses of enormous size, radiating huge amounts of energy into space and of special significance because they yield information on the extent of the universe and on the behavior and structure of matter under conditions of temperature and pressure not attainable in the laboratory. These remote, active heavenly bodies appeal to the imagination and offer problems of the most fascinating kind for solution. The astrophysicist is occupied with receiving and interpreting their messages. He learns little in this field from the moon. To him it is a lifeless, inert mass, shining only by reflected sunlight and held by gravitation in its orbit about the earth. From an astronomical viewpoint the moon is an insignificant object only 2,160 miles in diameter; the sun is nearly a million (864,000) miles in diameter. To us the moon appears large because it is distant only 30 earth's diameters or 240,000 miles. Viewed through a large telescope it appears to be only 200 or 300 miles away and details 500 feet apart can be distinguished under conditions of good seeing.

To the layman, not versed in astrophysics, the moon is the most conspicuous object in the night sky and the rival of all heavenly objects, even including the sun itself. It has played a significant part in many phases of human activity. To it we owe the first subdivision of the year into months and weeks, even though in our present calendar the lunar cycle is disregarded. The words moon and month are derived from the same Sanskrit root, *mâs*, meaning to measure. To our primitive ancestors the moon was an object of worship; they observed and tried to explain its changes in aspect and in position among the stars from day to day. Together with the sun it is responsible for the tides, so important to navigation. Its light illuminates the sky at night during a part of each month and its moonbeams are said to be an important factor in certain human decisions. To the formulation of the law of gravitation and to

[1] This article presents the progress made by the Committee on Study of the Surface Features of the Moon of the Carnegie Institution of Washington, of which the author is chairman.

the development of dynamical astronomy it contributed much; but to modern astrophysics it has added little and it can not compete with other heavenly bodies as an object of study. The astronomer of to-day does not appreciate the moon as did Milton when he wrote in "Paradise Lost":

> . . . The moon
> Rising in clouded majesty, at length
> Apparent queen, unveiled her peerless light
> And over the dark her silver mantle threw.

In 1609 Galileo first observed through his telescope the surface features of the moon, its craters, mountains and great plains or seas, as he called them. Realizing that the moon is a companion of the earth and, as he thought, a world not unlike our own, he was impressed by the features which he saw; and sought to interpret them in terms of terrestrial features. To him and to his contemporaries his telescope seemed to disclose a new world. Following his lead, astronomers undertook serious study of the moon's surface. During the next three centuries a vast amount of observational data on lunar surface features was accumulated and many lunar maps were published. As a result, the geography or rather selenography of the moon is well known; no part of the moon's surface visible to us has been left unexplored. Furthermore, selenologists have sought to explain the mode of formation of the different features on the moon's surface and have suggested all manner of hypotheses to account for them. In spite of all this labor we do not yet know definitely the exact nature of the lunar surface materials, nor how any single lunar feature was formed. No critical study and classification of lunar surface features have been made and no lunar maps free from the personal factor have been prepared.

Cooperative Approach

At the time the Committee on Study of the Surface Features of the Moon was appointed, Dr. John C. Merriam felt that attack by a cooperative Carnegie Institution group might be fruitful of results, especially if the experience from several branches of science could be brought to bear upon it. Accordingly he chose for membership on the committee four astrophysicists, one mathematical physicist, one geophysicist and two geologists.[2] The committee was given no specific instruction other than that implied in its title; it was afforded opportunity to contribute toward the solution of a most attractive problem, in part astrophysical, in part geological.

This policy of assigning to an interdepartmental committee a problem of large scope is in keeping with the general policy of the Carnegie Institution of supporting organized efforts in fields of science too large for one man to encompass. In the early days of science it was possible for one person to master all existing knowledge in his own field; advances were then made chiefly through the efforts of individual scientists working alone. These men laid the foundations on which modern science is being built. Each department of the Carnegie Institution is essentially a group of cooperating scientists, each member carrying on research activities of his own, but also doing his share of cooperative work. This group method of facing each problem from all standpoints and determining the best means for solving it is followed not only within each group, but also between the several groups within the institution and between the institution and outside agencies. The dividends accruing from cooperative work of this kind, in terms of scientific results obtained for a given sum of money, are

[2] Members of the committee are: W. S. Adams, F. G. Pease and E. Pettit, of Mt. Wilson Observatory; A. L. Day and F. E. Wright (chairman), of the Geophysical Laboratory; and research associates, H. N. Russell, of Princeton University, J. P. Buwalda and P. Epstein, of the California Institute of Technology.

FIG. 1. EARLY SKETCH MAP OF THE MOON
PREPARED BY P. CHERUBINO D'ORLEANS. PUBLISHED IN THE BOOK, "OCULUS ARTIFICIALIS TELEDIOPTRICUS SIVE TELESCOPIUM," BY J. ZAHN. NORIMBERGAE. 1702. REPRODUCED THROUGH THE COURTESY OF DR. J. C. HOSTETTER, CORNING, N. Y.

unusually large, chiefly because of facilities and the background of experience within the several groups. Were it not for this factor, the special interdepartmental and other cooperative activities would be less successful. On the other hand, the drawback to committee work of this nature is that no member can devote much time to it; results are, therefore, gathered slowly and the effort is spread over many years.

PRELIMINARY SURVEY

As a preliminary to experimental work on the problems presented by study of the surface features of the moon the committee undertook to survey the field and to analyze the present status of the problem. It sought to visualize the conditions existing at the moon's surface. The observer can not journey to the moon and gather samples, make maps and plot the field relations

on the spot. In geological field work geologists have become accustomed to judge of the relative effectiveness of different terrestrial agencies and are inclined to interpret what they see in terms of terrestrial factors or processes with which they have had experience. Moreover, the geologist sees what he has been trained to see and overlooks much that he would otherwise see had he the necessary background of experience. In study of the surface features of the moon he is confronted with conditions with which he has had no contact. Lunar surface features have been sculptured by catastrophic agents of different kinds and not by the action of running water, or by erosion and deposition in the usual sense, or by ordinary wind action, or by weathering. Gravity is only one sixth of that on the earth; a mass of rock weighing a ton on the earth would weigh only 333 pounds on the moon. At the moon's surface there is no water, no ice; no protective blanket of atmosphere to soften the impact of the sun's rays and to prevent the escape of heat radiated from the moon's surface. The temperature ranges are extreme. At midday on the moon, with the sun directly overhead, the surface temperature is approximately 120° C. (250° F.) or above that of boiling water; at midnight it falls to below –100° C. (–150° F.). In spite of this extreme range in surface temperatures it is probable that a few feet below the lunar surface the inflow of sun's radiation maintains a temperature not far from freezing, or 0° C.

It is not an easy task for the geologist to adjust his mental attitude to such extreme conditions. He has become accustomed, on viewing a given terrestrial surface feature, to inquire: (a) of what kinds of rocks or materials does it consist; (b) what geological agents, operating on the original rock mass, have given the surface feature its present shape? He has learned to recognize the imprint or earmark of each kind of geological agent and seeks in a given case to ascertain what combination of geological agents or processes, acting one after the other or together, have produced the surface feature under study. By this method he is able to read and to interpret geological history as it is written in the rocks and on their surface. In his study of the surface features of the moon he is confronted with physiographic forms which, in part, are quite unlike anything he has seen on the earth; also, he misses the familiar effects of erosion. To him the surface of the moon presents a weird picture. He realizes that before he can begin to make progress on lunar physiographic problems, he must first ascertain the nature of the materials which he sees exposed on the moon; then determine how those materials behave under the known lunar surface conditions. In other words, he must acquire a good working knowledge of the petrology of the lunar surface materials. In addition he needs a good lunar map, preferably a topographic map, by use of which he can obtain an idea of the spatial relations of the different features. This is asking a good deal and the task might seem hopeless were it not for the fact that messengers are continually reaching us from the moon in the form of reflected sun's rays; they will teach us much if we can decipher and interpret their messages correctly.

The Moon's Surface

The general features of the moon's surface are shown in Figs. 2 to 4. The dark smooth areas of Figs. 2 and 4 are called seas or maria; the lighter areas bordering the maria are the mountains; the features of circular outline are called craters because of their resemblance to terrestrial craters. The craters dominate many parts of the moon's sur-

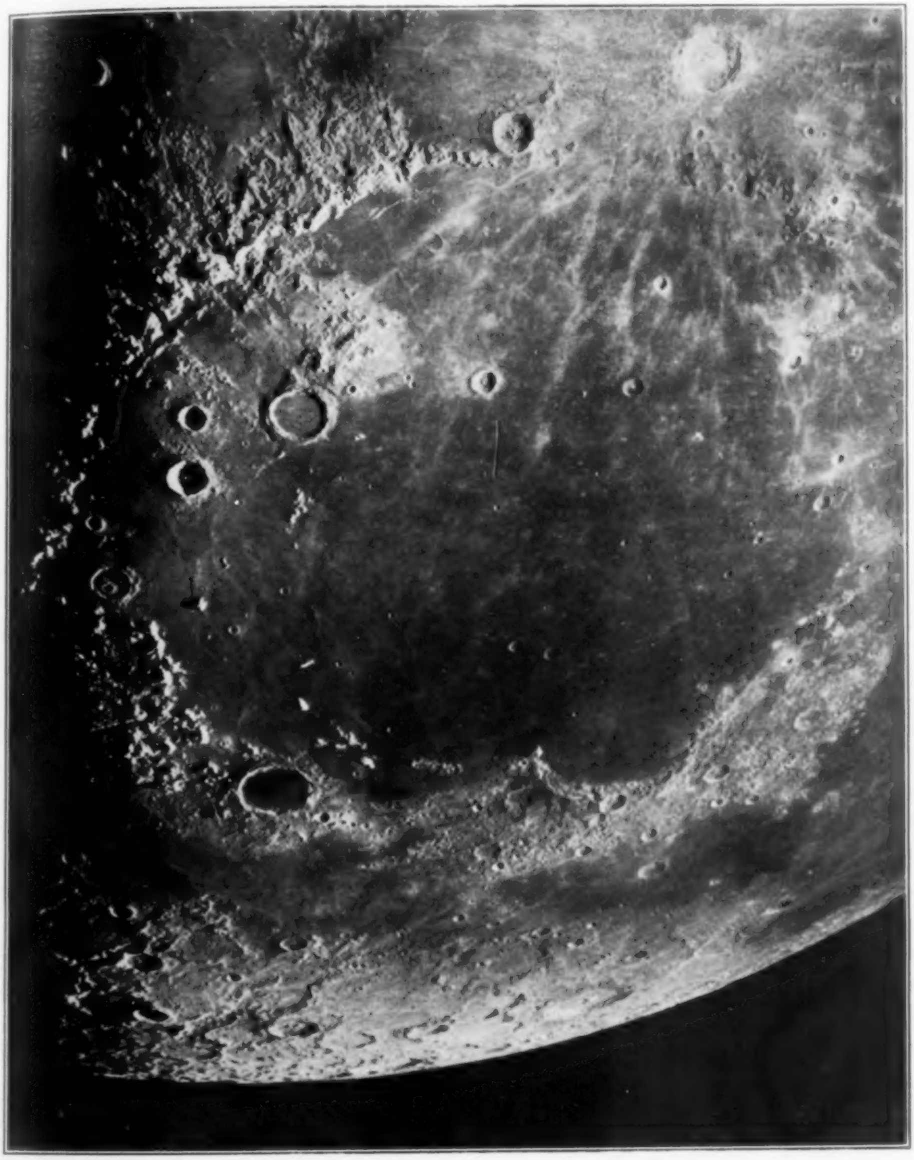


FIG. 2. NORTHEAST PORTION OF MOON'S SURFACE

MARE IMBRIUM OCCUPIES THE CENTRAL PART OF THIS VIEW. IT IS 800 MILES ACROSS AND IS BORDERED BY HIGH MOUNTAINS OF STRANGE ASPECT. OBSERVE THE DIVERSITY IN SIZES AND CHARACTERISTICS OF THE CIRCULAR FEATURES OR CRATERS. (PHOTOGRAPH BY F. G. PEASE, MT. WILSON OBSERVATORY, SEPTEMBER 15, 1919.)

face and are remarkable for their range in size and for their frequency. Of small craters there are literally thousands spread over the surface of the moon. The larger craters greatly exceed in dimensions terrestrial craters. Many of the craters, located in the maria, have smooth floors, level with the ground of the surrounding country; other craters are much deeper and less smooth; in many of these craters there is a central hill or series of peaks which rise from the crater floor; on several of these peaks there is perched, in turn, a small crater (Fig. 3). The area covered by a mare is greater than that of any one of the great plains regions of the earth. Mare Imbrium, which occupies the central portion of Fig. 2, is 800 miles across. The maria are relatively late formations and spread, as floods over preexisting craters and other features, submerging them either completely or nearly so.

One of the most impressive craters on the moon is Copernicus (Fig. 3); it is 56 miles across and 13,500 feet deep, about as deep as Mt. Blanc is high, and with central hills rising 2,400 feet above its floor. The simplest method for measuring the elevation of a lunar feature above the adjacent country is to ascertain the length of its shadow when it is near the terminator or the limit of illumination across the moon's disk. We know at any given time and for any point on the moon's surface the angle which the sun's rays make with the vertical to the moon's surface at that point, so that it is a simple task to compute from the given angle and the length of the shadow the height of the feature casting the shadow. Another method is based on the shift in longitude relations between adjacent features of different elevations with changes in libration. Still another method is the stereoscopic method, which also is based on phenomena due to libration. The terraced inner walls of Copernicus are conspicuous; also the rays or streaks which emanate from it and extend for great distances across Mare Imbrium. The most pronounced rays, however, radiate from Tycho (Fig. 4); this crater is 54 miles across and 17,000 feet deep; a central hill rises 5,200 feet from its floor. It is located in a part of the moon which is dominated by craters large and small and of different ages. The more recent craters are more sharply outlined and are lighter in color, as a general rule. Not far above Tycho in Fig. 4 is located Clavius, a magnificent crater 142 miles in diameter, 17,000 feet deep, and containing smaller craters, one of which is larger than any terrestrial crater. In this figure also a fault scarp is shown in the mare below Tycho which is called the Straight Wall; it is 70 miles long with a downthrow of nearly 1,000 feet on the east.

Study of the mountainous areas in the photographs and on other parts of the moon shows that they are unlike terrestrial mountains and are for the geologist and the astronomer exceedingly difficult to interpret. The heights of the mountains reach 25,000 feet in isolated cases; the deepest crater has a depth of 24,000 feet. The lunar mountains are extremely rough and would be difficult to traverse, even if there were water and air present to support life. This is not the place to discuss the many hypotheses which have been suggested to account for the mode of formation of the different types of lunar surface features. Suffice it to state that no single hypothesis has been adequately proved so that it can be accepted without reservations. Each hypothesis contains certain elements of truth. With reference to the volcanic theory of the origin of the craters, the observed intimate relationship between lunar crustal structure and the occurrence of craters indicates that some of the craters, at least, are due to volcanic action. On the other hand, the

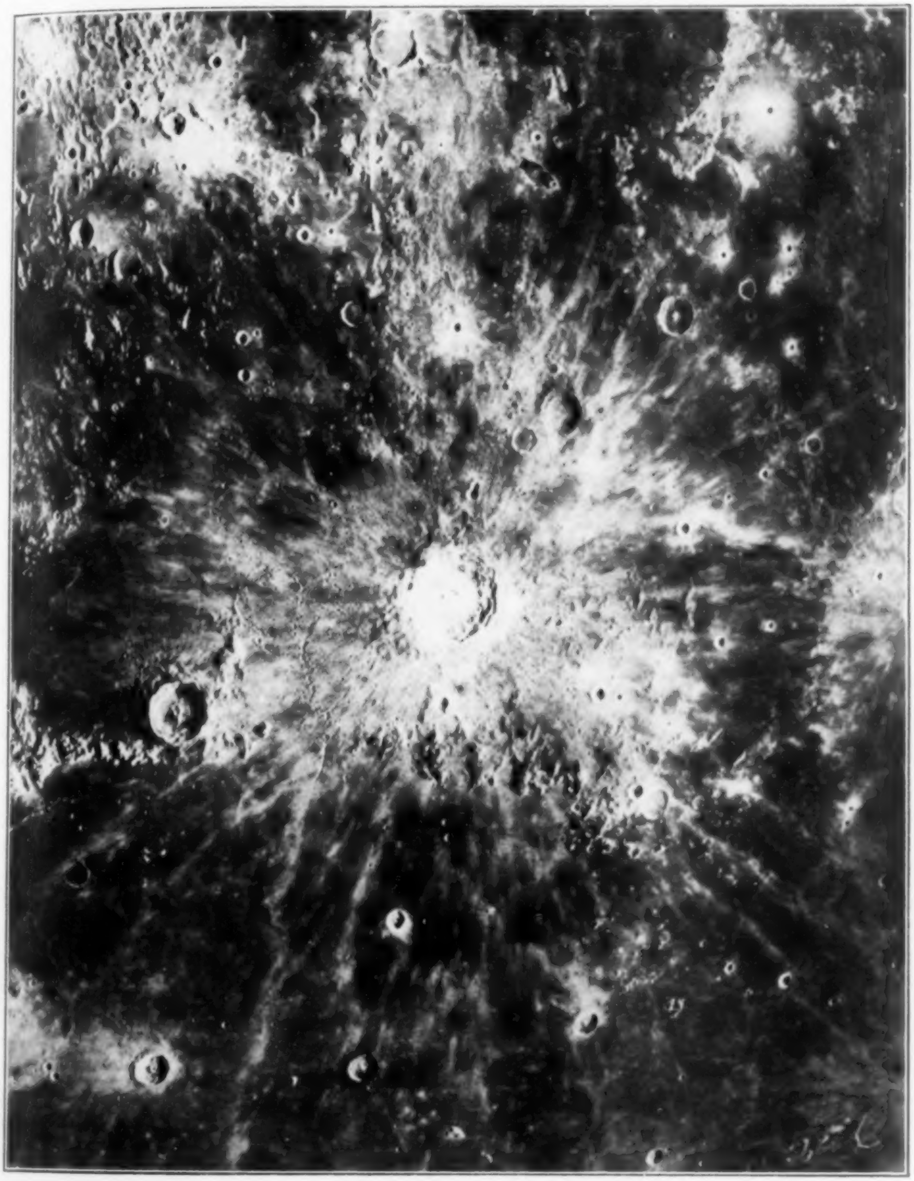


FIG. 3. EAST CENTRAL PORTION OF MOON'S SURFACE

COPERNICUS IS A MAGNIFICENT CRATER 56 MILES ACROSS AND DOMINATES THIS "METROPOLITAN" AREA OF THE MOON. OBSERVE THE STREAKS OR RAYS OF LIGHT MATERIALS WHICH RADIATE FROM COPERNICUS. (PHOTOGRAPH BY F. G. PEASE, MT. WILSON OBSERVATORY, SEPTEMBER 15, 1919.)

translational energy of a meteor impinging unimpeded on the moon with a velocity of 20 to 40 kilometers a second and penetrating into the surface for some distance is able not only to produce the crater form, but also on transformation of the residual kinetic energy into heat to melt and even to volatilize the country rock and thus set up actions which in their effects would closely resemble volcanic phenomena. In this connection the low lunar gravity is an important factor.

From a geological standpoint the absence of water and air on the moon together with its low gravity are factors favorable to the development and maintenance of extremes in surface forms. One of the results of low gravity and the lack of air resistance is the greatly increased length, 25 to 50 fold, of trajectories of materials thrown out of lunar craters as compared with the trajectories of materials ejected at the same initial velocity and angle of elevation on the earth. For a muzzle velocity of 1,600 meters (5,250 feet) per second, equal to that of the Big Bertha gun which the Germans used against Paris during the world war, the terrestrial range for an elevation angle of 50° is 75 miles; on the moon the maximum range for this initial velocity is 2,200 miles, or more than one quarter of the distance around the moon. The rays from Tycho have been traced for approximately 1,500 miles; for this distance an initial velocity of 1,480 meters (4,856 feet) per second is required and an elevation angle of 26°. An initial velocity of ejection from terrestrial volcanoes exceeding 2 kilometers a second has been deduced from observations of the volcano Cotopaxi. It is evident, therefore, that the ranges of ejection on the moon can easily have been produced by volcanic explosive forces comparable to those active on the earth. On the moon the materials ejected from a lunar crater are scattered far and wide, whereas on the earth the greater part of the ejected rock fragments and blocks fall near and into the crater orifice. As a result of this dispersion the lunar craters are cleaned out as a rule and are of the nature of deep holes in the ground with the floor of the crater below the level of the surrounding country; the floors of terrestrial craters, on the other hand, are near the top of the crater and high above the level of the adjacent country. This is one of the factors to be taken into account in a study of lunar craters. It is not permissible to conclude that, because the shape of a lunar crater is similar to that of a terrestrial crater the mode of formation of the two was the same.

Mapping the Moon

Before the geologist can make satisfactory progress in lunar physiographic studies he must have a topographic map, at least of the central portion, to aid him in visualizing the shapes of the lunar surface features and of their relations one to another. He can then classify the features, and by studying them in detail can acquire a background of experience in lunar geology which is necessary to competent interpretation of the phenomena observed.

Of maps there are two kinds, the plan or base map and the topographic. Thus far, for the moon, only the first kind has been attempted. It represents the moon's globular surface projected on a definite plane and shows the features somewhat as the astronomer sees them through his telescope. These maps have been drawn by astronomers untrained in the principles of map-making, with the result that existing maps are unsatisfactory in several respects; the balance between map scale and amount of detail shown is not realized and some of the maps are not easily legible; several lunar maps have been prepared by men

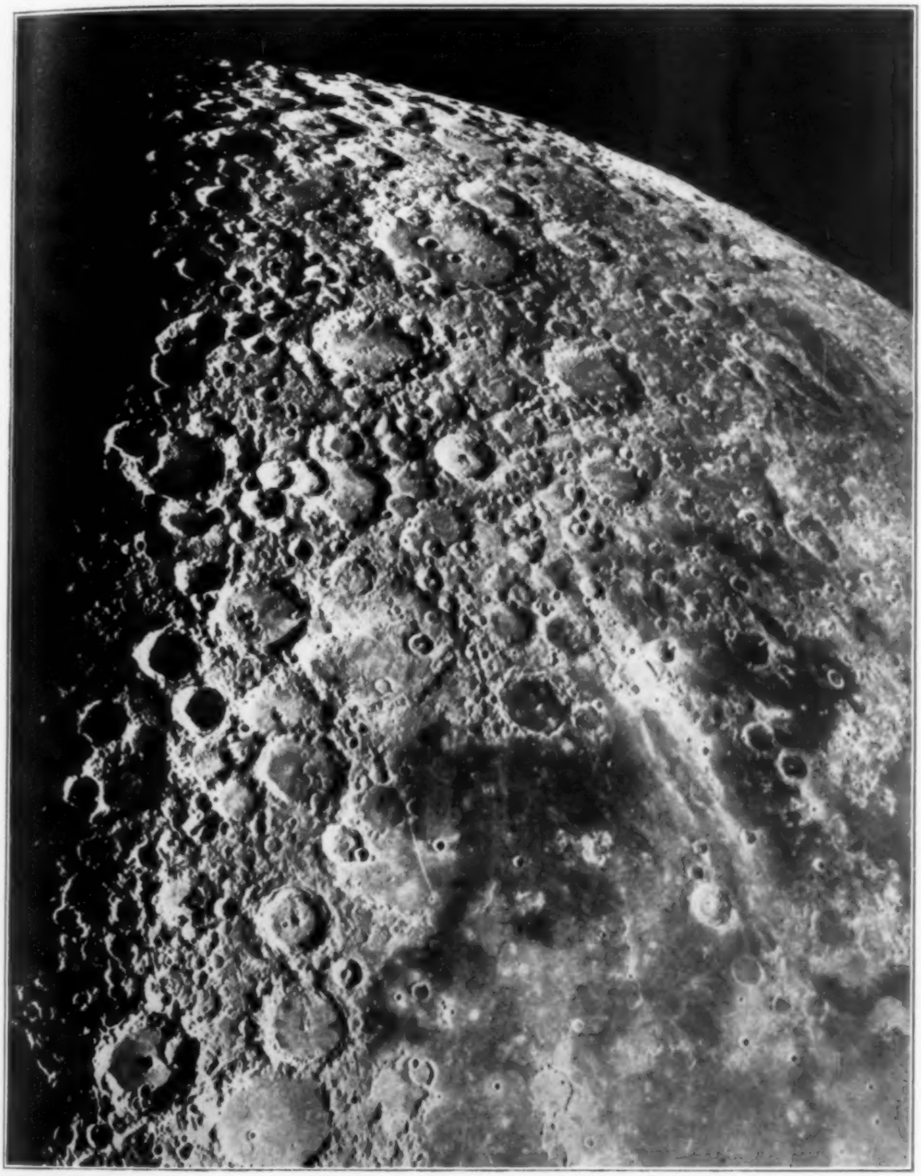


FIG. 4. SOUTHEAST SECTION OF MOON'S SURFACE

THE LARGE, SHARPLY DEFINED CRATER NEAR THE CENTER OF THE VIEW IS TYCHO. IT IS 17,000 FEET DEEP AND 54 MILES ACROSS; FROM IT WHITE STREAKS RADIATE FOR LONG DISTANCES. CLAVIUS, A STILL LARGER CRATER, 142 MILES IN DIAMETER AND LOCATED ABOVE TYCHO, IS ONE OF THE MOST INTERESTING FEATURES ON THE MOON. (PHOTOGRAPH BY F. G. PEASE, MT. WILSON OBSERVATORY, SEPTEMBER 15, 1919.)

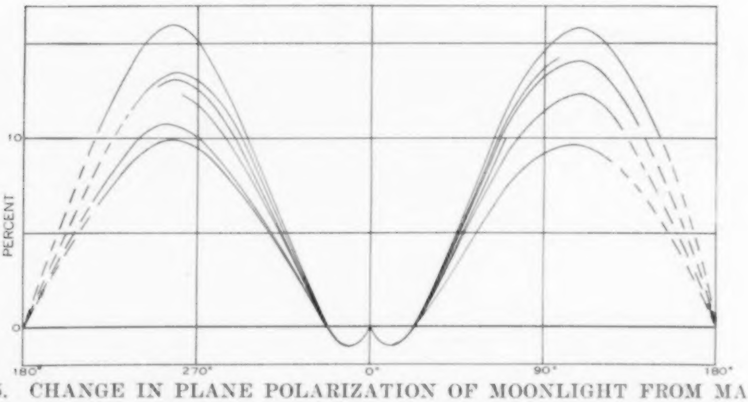


FIG. 5. CHANGE IN PLANE POLARIZATION OF MOONLIGHT FROM MARIA

THE CURVES SHOW THE CHANGES IN PERCENTAGE PLANE POLARIZATION OF MOONLIGHT FROM DIFFERENT LUNAR MARIA WITH CHANGE IN PHASE ANGLE.

who were good observers, but not good draughtsmen and unable to portray what they saw. In other words, the existing maps suffer from the personal equations of the men who drew them. Comparison of a lunar map made a century ago with one made recently shows marked differences in the representation of certain features; on the basis of such a comparison it has been concluded that changes have taken place here and there on the moon. But astronomers do not agree as to the validity of any single change, and the bulk of the available evidence goes to show that there has been no appreciable change on the moon's surface within the past century.

It seemed, therefore, to the moon committee that a lunar map should be prepared which is free from the personal equation and not dependent on the skill of the observer to depict correctly what he sees on the surface of the moon. The positions of approximately 4,000 points on the moon's surface have been accurately measured by Saunders, Franz and others and expressed in terms of selenographic longitude and latitude. With the aid of these data on position it is possible to ascertain the amount and direction of libration in each photograph of the moon. If each photograph could be transformed so that its plane coincides with the plane of mean libration, namely, the plane on which all lunar maps are projected, the transformed photograph would form part of a lunar map and at the same time be free from the personal equation of the one who makes the map. To prepare a photographic map of the moon it is necessary to transform photographs taken with the aid of the 100-inch telescope at Mt. Wilson so that the plane of projection is the same for all photographs. A map is a projection on a definite plane; the type of projection and the plane of projection must be quite definite if the map is to be satisfactory. For the transformation of the photographs a special moon house has been built at Mt. Wilson. It is a specially insulated structure with double walls, corrugated sheet iron on the outside and paper on the inside with ventilation between the walls so that they quickly respond to temperature changes outside. The floor is covered with a layer of sawdust six inches thick to prevent radiation from the ground. As a result, the temperature distribution within the 150-foot building is remarkably uniform and seeing conditions are good so long as the temperature outside is not changing rapidly and there is no appreciable wind.

To transform a given moon photo-

graph taken at the Cassegrain focus of the 100-inch telescope (focal length 135 feet), the moon positive, 15 inches in diameter, is mounted in front of a powerful beam of light reflected by an Army searchlight mirror 3 feet in diameter; the light passes through the positive to a parabolic silvered mirror of 67.5 feet focal length and 135 feet distant and thence back to a carefully turned globe of bronze, 15 inches in diameter and coated with magnesia powder. This coating furnishes a white diffuse reflecting surface. The image of the moon formed on it is in all respects similar to the moon in the relations of the surface features one to the other; in other words, it is a miniature moon which can be photographed from any direction. For this purpose a second reflecting mirror, also of 67.5 feet focal length, is placed at such a position that it views the moon from the direction of mean libration and casts an image of it on a photographic plate mounted in a compartment beside the illuminated globe. The photographs thus produced are projections on the plane of mean libration; they fulfil the requirements of a map on a given scale. In order to complete the series of maps showing the moon at different phases we still need photographs taken with the 100-inch telescope and its zero corrector lens. During the past two years the seeing conditions at Mt. Wilson have not been such that we could obtain photographs of the quality desired for this purpose. The series of maps made by this method will be independent of the personal factor and be more valuable a century hence than at present.

Photograph of Moon on Globe

The projection of the moon positive on the magnesia-coated globe gives a surprisingly beautiful and realistic representation of the moon's surface. The correct and undistorted appearance of the craters and other features near the edge of the moon's disk is of great aid in the visualization of the surface relationships. In order to make this globular representation more accessible, a glass globe coated on the outside with photographic emulsion was substituted for the magnesia-coated bronze globe and the moon negative projected on it, thus producing a moon transparency which is angle true. The globe is frosted on the inside and illuminated by an electric bulb. The coating with photographic emulsion was done, through the courtesy of Dr. C. E. K. Mees, by the Research Laboratory of the Eastman Kodak Company, and represents a new advance in photographic technique. A

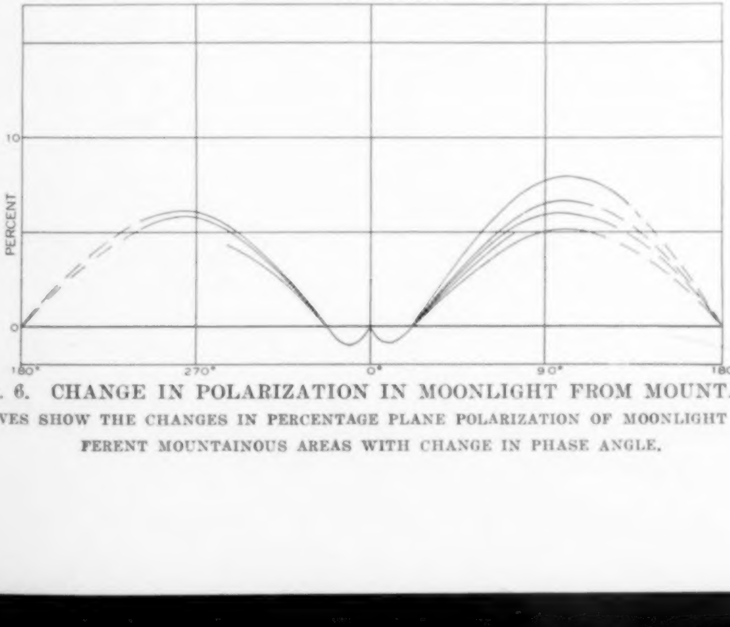


FIG. 6. CHANGE IN POLARIZATION IN MOONLIGHT FROM MOUNTAINS

THE CURVES SHOW THE CHANGES IN PERCENTAGE PLANE POLARIZATION OF MOONLIGHT FROM DIFFERENT MOUNTAINOUS AREAS WITH CHANGE IN PHASE ANGLE.

dozen of these globes have been prepared; they will be useful to the moon committee in its physiographic work later; they may also serve as exhibits of miniature moons showing the moon at different phases.

The committee has also devised a method for making a topographic map of the central part of the moon out to 45° from the center and with contour intervals of 500 feet or 200 meters. For the preparation of this map advantage is taken of the libration of the moon to obtain stereoscopic images from which, in turn, the relative elevations can be ascertained by applying the principle used in areal mapping from airplane photographs; with this difference, however, that in airplane mapping the surface of reference or datum plane is a horizontal plane, whereas on the moon we are interested in the elevations with reference to a mean spherical surface. The apparatus has not yet been built, and we shall not stop to consider details of the method.

Surface Composition

We come now to the problem of ascertaining the nature of the materials exposed at the surface of the moon. Obviously, we are limited, in our approach to the problem, to a determination of the effects which the materials have on sunlight on reflection. One and a quarter seconds after the sun's rays leave the moon they reach the earth. We can study and measure these reflected rays by different methods and compare them with direct rays from the sun. We can also study and measure the changes produced in sun's rays on reflection by terrestrial materials, such as rocks of various kinds and other substances. These changes are not limited to the visible spectrum, but include all the radiation received through the earth's atmosphere from the ultra-violet into the infra-red. The effects produced are of two kinds: a certain amount of plane polarization is introduced and different parts of the spectrum are reflected to different degrees. Light is considered to be caused by vibrations in a special medium. These vibrations take place, in free space, at right angles to the direction of propagation. If the vibrations are limited to a single plane containing the direction of propagation and a line perpendicular thereto the light is said to be plane polarized. White light consists of vibrations of different frequencies; it can be resolved into its component parts or frequencies by the use of a spectroscope or spectrograph. The human eye is sensitive to a small part only of the range of radiation frequencies; this part is called the visible spectrum; those portions which are beyond the power of the eye to sense are called the ultra-violet and the infra-red, respectively, when the frequencies are higher or lower than the frequencies in the visible spectrum.

Thus far we have used, and are still using, four different methods for these measurements; a visual method employing a special polarization eyepiece for the measurement of the amount of plane polarization in the rays for different points on the moon's surface and at different phases of the moon; a photoelectric-cell method for the measurement both of the amount of plane polarization and of the relative spectral intensities of the rays; a thermoelement method for the same purpose; and a polarization spectrograph. These methods require special apparatus, devised or adapted to the problem in hand. The moon is an unusually favorable object for the testing of new methods and apparatus suitable for analyzing the characteristics of sunlight reflected by a planet or satellite of the solar system.

For the visual measurements a special eyepiece enables us to ascertain the percentage plane polarization in a moonbeam accurate to one fifth of one per

cent. The field of the eyepiece is a divided photometric field in which two factors, equality of illumination and exact alignment of Savart fringes, are the two criteria used in making a measurement; it is the combination of these two factors which renders the method so accurate. With the aid of this eyepiece 24 selected small areas on the moon have been studied and the amounts of plane polarization in the reflected light measured for different phases of the moon. The measurements extended over four lunations, and nearly 10,000 individual readings with the new eyepiece mounted on a six-inch refracting telescope were made, so that we now know with a fair degree of certainty the amount of plane polarization present in a beam of moonlight from any given area on the moon at any given phase. The general results are shown in Figs. 5 and 6. On an average the mountains and lighter areas reflect more light and contain approximately half as much plane polarized light as the light from the maria and other dark areas. The maximum polarization occurs at the lunar phase angles, 100° to 110° and 280° to 290°, and attains the maximum value of 16 per cent. in the case of one or two maria. The plane of vibration is commonly normal to the plane of incidence; but near full moon the polarization is negative and the plane of vibration is in the plane of incidence. At phase angles, $\pm 22°$ to 23°, the polarization is zero for practically all points on the moon's surface. It is also zero for phase angles 0° (full moon) and 180° (new moon). This negative polarization, first discovered by Lyot, attains a value roughly of one per cent. as a rule. It is an abnormal phenomenon and is probably due to diffraction and scattering. It is also observed on terrestrial materials.

Measurements of the percentage amounts of plane polarization in sunlight reflected by terrestrial materials are being made with the new eyepiece; they are not yet complete. When finished, they will enable us to group the materials according to this property and thus to ascertain with a fair degree of probability the nature of the lunar surface materials. We know from measurements made with the less accurate predecessor to this eyepiece that dark, opaque rocks and other substances polarize the light more or less completely at certain phase angles; whereas light-colored rocks and materials, into which the light can penetrate and be reflected, polarize the light relatively little, thus indicating that the lunar surface materials are of the latter type. Additional evidence that the surface materials are of the nature of volcanic ashes and pumice, high in silica, is given by the rate of cooling of the moon's surface during an eclipse. As the earth's shadow passes over the moon its surface temperature drops, in the course of an hour, from +120° C. to below −100° C., according to measurements by Pettit and Nicholson of Mt. Wilson Observatory. This signifies, as computations by Dr. Epstein of our committee show, that the lunar surface materials are exceedingly good heat insulators; in other words, they have very small heat capacity, are poor heat conductors and can not, therefore, be massive materials, like granite or limestone, but rather light substances resembling, in characteristics, pumice and volcanic ashes.

Measurements by the three other methods, photoelectric cell, thermoelement and the polarization spectrograph, are now in progress. In these three methods the special apparatus is mounted on a 20-inch reflecting telescope and the light from a given small area on the moon is received on the light-sensitive receiver. The photoelectric cell attachment consists of a special large compound Wollaston prism of quartz in a rotatable mount, a vacuum potassium

Kunz photocell of fused quartz, and the special amplifying circuit of DuBridge and Brown adapted and improved by Dr. Stebbins and employing the new electrometer tube, D–96475, of the Western Electric Company. A more refined apparatus of this type is employed by Dr. Stebbins in his work with the photoelectric cell on the stars and nebulæ. The thermoelement is of the vacuum type, made by Dr. E. Pettit, and is equipped with the rotatable compound Wollaston prism of quartz; like the photocell it is used together with ray filters to isolate certain parts of the spectrum. The thermoelement is not nearly so sensitive as the photocell, but it extends over the entire spectrum and is useful as a check on the other measurements. The polarization spectrograph is of the ultra-violet type but also serves throughout the visible spectrum. In the parallel beam between the collimator and the first prism a Wollaston prism of quartz in a sliding mount can be inserted and two spectra obtained, the one with vibrations in the plane of incidence and the second with vibrations normal thereto. Approximately 200 spectrograms of different parts of the moon were taken with this spectrograph during the past summer. The spectrograms yield information both on the percentage polarization for any given wave-length and on the relative intensities for different wave-lengths. Although not so sensitive as the photoelectric cell, the polarization spectrograph covers a much wider range of wave-lengths, through the ultra-violet into the deep red of the visible spectrum.

Program for Further Work

We plan to complete these measurements within the next two or three years; also to measure the changes in polarization of total moonlight with change in phase and for different parts of the spectrum; also the change in total intensity of moonlight with change in phase; also to obtain additional photographs of satisfactory quality to enable us to proceed with the preparation of the photographic lunar map. We are working along quite definite lines with apparatus and methods developed in detail. We shall gather data of measurement which should enable us to ascertain with fair certainty what the lunar surface materials are and how they are disposed over the surface of the moon in so far as it is visible to us. With that information available, together with a good lunar map and a knowledge of the conditions existing at the surface of the moon, we shall be in a position to attack the problem of the physiography and mode of formation of the lunar surface features.

The question arises: Why should a problem of this sort be solved? Why should a scientist give of his time and energy to their solution? These are proper questions and they should be faced. The scientific spirit of the investigator impels him to search after the truth and to do so by experiment and measurement. His interest is objective and is centered chiefly in the overcoming of difficulties incident to the pioneer work of advancing knowledge. For the most part he is the expert workman, operating through his fingers, using tools of his own design and adding his bit to the fund of knowledge. In the case of a problem like that of the moon, he does not inquire too closely into the immediate usefulness of the results obtained; his first desire and task is to devise methods and apparatus adequate for the attack. The routine measurements needed to obtain the results are a necessary step toward the solution. That these methods and devices will have

application to other problems of similar nature is to him a satisfaction; but the real incentive is the game of overcoming the difficulties inherent in the problem.

Experience has shown that scientific research work does yield returns, even when the research problem is in the field of astronomy. The several fields of science are so intimately related that advance in the one field commonly means advance in another. The practical applications of the results of science and of its method of approach have meant much to us in a physical and materialistic sense; but equally important is the training in attitude of mind toward nature, its constancy and reliability. We research workers fail in our task if we do not pass on some of the inspiration we derive from close contact with nature, its forces and factors which are quite beyond our comprehension. We glimpse these elements from afar and realize with humility how limited is our understanding of even simple things. But we do sense a goal which, if it were more generally realized, would add stability and proper placing of emphasis on the things that count and tend to bring us into accord with the principles of life which endure and have stood the test of time and human experience.

PERSIA—A LAND OF MEDIEVAL FARMING

By ALFRED HEINICKE

WALDHEIM-SAXONY, GERMANY

YEARS before biblical history touched hands with Persia, there was a comparatively advanced state of civilization in that exceedingly ancient country. Great wealth and never-failing romance were associated with it. Lovely women adorned with costly pearls, gallant soldiers with diamonds glittering in their swords and daggers, flash across the stage of Persia's changeful history. The wise Darius, the brilliant Cyrus, the March of the Ten Thousand detailed by Xenophon until its thrilling culmination bursts on one in the thanksgiving cry "Thalassa! Thalassa!" when the soldiers catch a glimpse of the "twinkling footed" sea, all these things remind us of a glorious past, when Persia filled a great space upon the world's stage of events. . . .

And to-day? Western civilization as yet has made little impression on the great old empire. Western progress, the modern inventions in agricultural machinery and scientific methods of cultivation have passed over this country without leaving any signs on its agriculture. The land is still tilled in much the same way as in the days of the Great Cyrus. . . . The simplest and most primitive tools and implements are employed to break up and prepare the soil. The plough, drawn by a pair of Zebus, is a very crude affair. The share, made of soft iron imported from Europe, is attached to rough wooden bars made by the village carpenter, and the plough is fastened to the heavy yoke by a chain. . . . The soil is merely scratched on the surface, for the depth to which the share penetrates depends entirely on the physical exertion of the driver, who is often merely a youth. . . .

ROLLING WITH A PLANK

As soon as the rainy season sets in, generally in November, field work begins. Only two kinds of grain are grown in Fars, the most fertile part in Southern Persia—wheat for bread, and barley for the food of the horses, donkeys and mules, although the latter is often used for food by the poorest classes. . . . When the seed has been sown, a plank five feet long by one and a half feet broad, weighted by the driver standing on it, is driven over the ground to level it, and to cover the seed so that it may not be washed out of place when the fields are flooded. If the rains are abundant, the young green blades soon show above the ground, but if the rains fail, irrigation must be resorted to. Then the few springs which exist in the Shiraz valley become worth a good deal of money. . . . Water is very scarce in Southern Persia and has to be bought by most farmers throughout the dry season from April to November. On specified days in the week each field owner gets his supply for certain hours. The fields are then flooded. To retain the water as much as possible each group of fields is divided by numbers of bolks two feet high, which confine the water. In this way the earth is thoroughly soaked. . . .

PRIMITIVE IRRIGATION

Where running water is not obtainable, wells are dug. From these wells, some of which are as much as sixty or a hundred feet deep, the water is drawn by horses or other animals. A rope attached to the harness runs over a wooden wheel above the well's mouth. The "bucket" consists of the skin of a sheep or goat, from the neck of which the water flows into a basin level with the ground and then through narrow channels to the growing crops. These wells can be seen and the squeaking noise of the wooden wheels heard throughout the land. Supplementing the wells as

PLOUGHING IN PERSIA.

AS SOON IN NOVEMBER AS THE FIRST RAINS HAVE FALLEN, THE FARMER PLOUGHS HIS LAND WITH THE PRIMITIVE PLOUGH SHOWN IN THE PICTURE.

THE IRRIGATION SYSTEM.

AS SOON AS THE FIELD IS PLOUGHED THE CHANNELS FOR IRRIGATION ARE DRAWN OVER THE FIELD, AND WHEN IRRIGATED EACH PORTION IS SOAKED THOROUGHLY. THIS IS GENERALLY DONE ONCE A WEEK.

A FIELD PREPARED FOR IRRIGATION.

ALONG THE SMALL BALKS SEEN IN THE PHOTOGRAPH RUNS THE CHANNEL FOR THE WATER.

CLEANING THE AQUEDUCT.

THE WAY IN WHICH AN IRRIGATION UNDERGROUND AQUEDUCT IS CLEANED OF THE MUD COLLECTED DURING SEVERAL YEARS. A MAN IS IN THE AQUEDUCT TO SHOVEL THE MUD INTO BUCKETS. THE MAN AT THE WHEEL PULLS IT UP.

sources of irrigation water are aqueducts, very often many miles long, and running usually underground, through which the water is led from the mountains to the plains and villages. The soil thrown up in digging these passages forms mounds at the mouth of the shafts which are sunk at intervals of twenty-five or thirty yards. The digging of these canals is a special trade and the secret of their construction is guarded jealously by the men who earn their living in this manner.

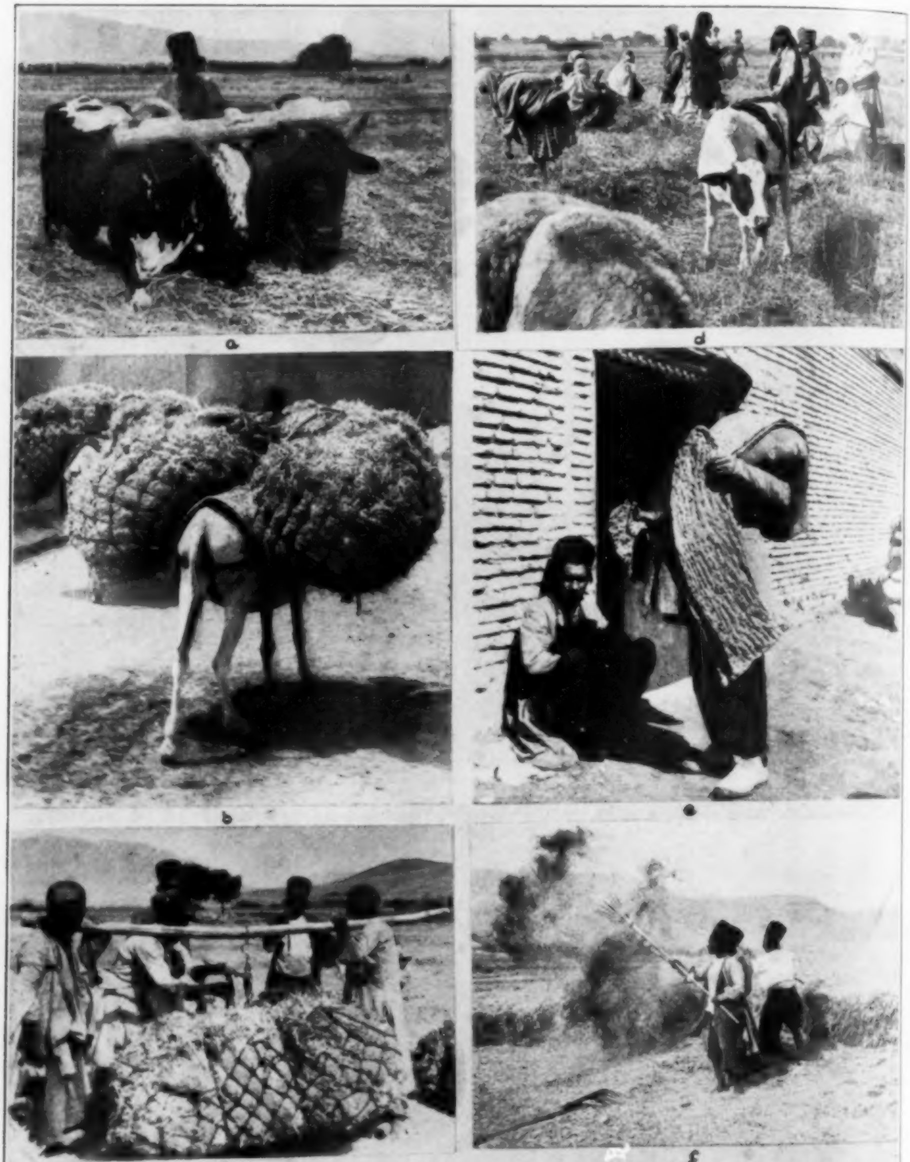
The crops begin to ripen and the harvesting starts about July in the Shiraz valley, but earlier as one goes farther south. The simple sickle is the only reaping implement used all over the country. When the crop is reaped, it is not tied into sheaves, but is merely stacked up, as hay is treated in England.

Threshing Machine Uses Cow Power

When threshing time arrives the simplest of machines appears on the scene. This is a combined thresher and chaff cutter. Between two broad, wooden runners there is a pair of wooden rollers in which short, wide, blunt knife-blades are fixed. The upper part consists of four wooden uprights on which a very small board is mounted, as seat for the driver. A pair of Zebus drags this machine over the straw, which is spread flat on the ground and is cut or rather broken up by the constantly rotating knives, while the pressure of the runners separates the grain from the husks. The weight of the driver supplies the necessary pressure. It takes eight or ten days to thresh out a stack, and when this is finished, if the wind is blowing freshly the winnowing can begin. Again a very simple instrument, merely a wooden fork, is all that is used by the peasants. The monsoon, which blows in August and September over Southern Persia, plays an important part in this proceeding. The winnowers start on the weather side of the threshed stack, tossing the chopped straw into the air with their forks, the breeze blows the light chaff several yards to leeward, where it collects in a heap, while the heavy grain falls at the feet of the work-

ON A PERSIAN FARM.

a, A WELL FOR IRRIGATION. b, CUTTING THE GRAIN WITH THE SIMPLE SICKLE. c, THE PERSIAN SLED-LIKE THRESHING MACHINE WITH THE KNIVES ON THE ROLLERS.



HARVESTING THE GRAIN.

a, THRESHING THE GRAIN. b, BRINGING IN THE CHAFF. c, WEIGHING THE CHAFF. d, WHEN THE FIELD IS FINISHED THE POOR GLEAN THE FIELD. e, THIS IS THE PANCAKE-LIKE PERSIAN BREAD. HALF-WARM IT TASTES BEST. f, WINNOWING THE THRESHED GRAIN AT THE BEGINNING.

A STACK HALF WAY THRESHED. THE DRIVER SITS ON THE MACHINE AS WEIGHT.

ers and in this rough-and-ready manner the separation of the grain from the chaff is effected.

Gleaning Still Permitted

The remaining operations of harvesting are very simple. The chaff is baled up in large specially made nets, and brought on donkeys to the villages, while the grain follows in bags on the backs of mules or horses. The poor people are now allowed to glean over the fields, sifting the dust and gathering such grain and chaff as is left. Before the grain goes to the flour mill, it is cleaned once more in a stone mortar with heavy wooden pestles, to get rid of the remaining husks.

The Persian wheat bread is sold in flat pancake-like pieces called "sangak" (from *sang,* the stone), due to the fact that it is baked in an oven with a floor of heated pebbles. As it is so thin, it is baked thoroughly and tastes best while still warm. As the poorer classes all over the south of Persia live on nothing else but bread, the harvest means everything to them, and the price of wheat is a most serious matter. . . . Bread riots break out if prices reach the famine point, and are a source of much trouble to the government. Therefore it is the aim of the new Shah Reza Khan to build several big dams to impound all the rain water which otherwise flows to waste during the wet season from November to March every year. Such plans when realized will be a great blessing for the country, since thereby a lot of waste land will be turned into fertile grain fields to feed additional thousands of people. The importance of such measures may be appreciated, since Persia has only one third of its ground under cultivation, due in many parts to the scarcity of water. Since I returned from Persia many new suggestions have been proposed to increase the water of irrigation. So far the lack of capital has prevented their realization. The word of Cyrus to Xenophon is still true: "My father's empire is so great that the people freeze to death at one end and die of thirst at the other."

SOME BOTANICAL ASPECTS OF PERISHABLE FOOD PRODUCTS

By Dr. CHARLES BROOKS

BUREAU OF PLANT INDUSTRY, U. S. DEPARTMENT OF AGRICULTURE

It is not unusual to find a non-botanical individual who does not think of harvested products as actually alive and who is surprised to learn that apples and oranges are really carrying on respiration. It is also not unusual to find a botanist whose conversation would indicate that in his opinion the things of real botanical interest are confined to the great outdoors. Plant physiologies, plant pathologies and other botanical texts, even the most recent ones, have very little space given to after-harvest botanical activities, and the same is true of the courses planned for students in high school and college.

There is some justification for this situation. The harvested product does not represent the full range of botanical activities. Photosynthesis is a thing of the past and there is no longer the mooted question as to how the soil stream makes its ascent. Transpiration, however, is still an important factor, and respiration with its related metabolic activities has come to the front as the major consideration. There is no longer the interesting question as to what the product is going to become but rather the question as to how long it is going to survive. The problems are mainly those of senescence rather than youth. The metabolism has more of the destructive than the constructive.

Harvest time marks a great change not only in the plant activities but in man's attitude towards them. Prior to harvest, man resorts to every feasible means to increase the plant processes by such agencies as fertilizers, irrigation and cultivation. After harvest he looks for every possible means of slowing down the natural plant processes. His interest is in finding the best manner of putting on the brakes, and in seeing how tightly they can be set without wrecking the machine.

In spite of the more limited range of activities many interesting problems are involved in the botany of the harvested product and many that have an important bearing on our every-day life—on what we eat, how it tastes and what we pay for it. These problems have been intensified by the fact that in present-day living the producer and consumer are usually separate parties and often long distances apart. The percentage of food that is consumed by the families that produce it has become extremely small. Even the farmer draws heavily on the local market for a great variety of food materials, and the stacks of fruits and vegetables in the receiving markets of our large cities are an almost unbelievable sight. To give the actual quantity in bushels or even in carlots would run into figures too large to be readily comprehended. All this volume of material is carrying on botanical activities from the time it is harvested till the time it passes into consumption. The methods of handling should be based on botanical laws. In actual practise these laws are not infrequently violated and the consumer foots the bill, either in the price he pays or in the poor quality of food he receives.

For one who feels inclined to study the night life of a large city, the New York fruit and vegetable piers offer a good place to start. There is plenty

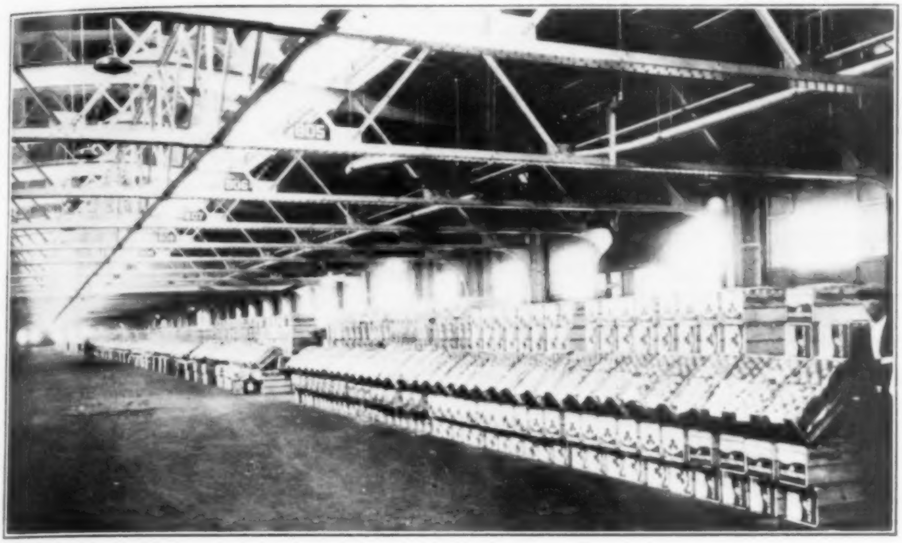


FIG. 1. NEW YORK PIER,
SHOWING PART OF THE DAILY SUPPLY OF CITRUS.

doing all night through and well on into the next day (Fig. 1).

After-harvest botany is one of the newer and younger fields of botanical activity confined largely to the present century and having its real beginning in the Paris Exposition of 1900. It has not been taken up as a fad but rather as a necessity, as a result of our changed methods of living. Research in the field has been confined almost entirely to institutions supported by public funds; outstanding among these have been the U. S. Department of Agriculture and some half dozen state experiment stations. Older institutions like Harvard and Yale have contributed little. Since the world war England has come into the field in a most aggressive manner and with excellent results. The world war apparently aroused greater interest in the maintenance of a satisfactory food supply. South Africa, Australia and New Zealand have followed in a minor way, and the latest convert is Italy.

A recent Italian publication, "Annali della Sperimentazione Agraria," contains a half dozen or more articles on transportation and storage of fruits, vegetables and flowers, illustrated with a large number of excellent colored plates. This is a new field for Italy, and judging by the number of workers reporting and by the elaborateness of the publications, it is one in which she plans to take an active part.

The reason for this new activity in Italy lies in the fact that the orchard areas that are coming into production are certain to produce a surplus, for which distant markets must be developed. This is not unlike the demands that have arisen in the United States. The call for help has usually come from the producers who were looking for a market, and if a better method of handling a product has been discovered, the value of the discovery has usually been measured in terms of the benefit to the particular group of producers. The fact seems to be overlooked that improving the shipping or marketing conditions for one group of producers sometimes

drives others to the wall and that the greatest importance of the accomplishment lies in the benefits given the consumers. That a small group of producers has found a more profitable market is actually a small item compared with the fact that many millions of people may have been supplied with a cheaper, better balanced or more healthful diet.

Every movement has its pioneers and leaders around whom growth and progress have centered, and after-harvest botany is no exception. Much of the progress in this field during the last 35 years, during practically its entire period of development, has centered around one individual, Dr. W. A. Taylor, chief of the Bureau of Plant Industry. He has been continuously outstanding both as pioneer and leader. An already recognized authority on after-harvest conditions, it was his responsibility to see that American fruit was kept continuously on display in good condition at the Paris Exposition of 1900. Selected lots of apples of the leading commercial varieties from 17

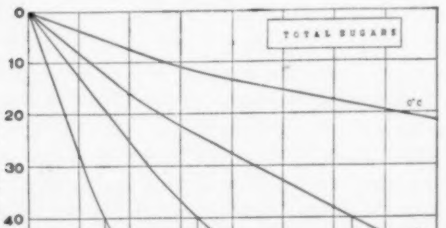


FIG. 2. DEPLETION OF TOTAL SUGARS IN GREEN SWEET CORN DURING CONSECUTIVE 24-HOUR PERIODS OF STORAGE AT DIFFERENT TEMPERATURES. THE ORDINATES ARE GIVEN BY THE NUMBERS ON THE LEFT OF THE FIGURE AND REPRESENT THE LOSS OF SUGAR EXPRESSED AS PERCENTAGES OF THE INITIAL SUGAR, WHICH WAS 5.91 PER CENT., WET WEIGHT. APPLEMAN AND ARTHUR.

different states were assembled in cold storage in the fall of 1899 and later transported overseas under refrigeration for exhibition purposes. It was Dr. Taylor's observations on the diseases and behavior of this fruit that resulted in the inauguration in the Bureau of Plant Industry of the U. S. Department of Agriculture of systematic experimental investigation of the effect of environmental conditions upon fruits and vegetables in storage and transit.

In the Yearbook of the U. S. Department of Agriculture of 1900 Dr. Taylor has an article on "The Influence of Refrigeration on the Fruit Industry," a fascinating report of early patents and devices for refrigerator cars and cold storage rooms, with notes on the successes and failures in the control of diseases. Papers followed reporting difficulties in fruit handling, such as the spoilage of stone fruits in the top layers of the car and the development of scald on apples in storage, and then a series of papers by others, but all mentioning his cooperation and direction and all apparently initiated by his grasp of the needs of the industry. In this series came "The Apple in Cold Storage" and "Cold Storage with Special Reference to the Pear and Peach," by Powell and Fulton, of the Bureau of Plant Industry, both publications in 1903, and "Studies on Apples" by Bigelow, Gore and Howard, of the Bureau of Chemistry, in 1905. These papers marked practically the first real attempt to bring scientific investigation to the service of the public in the study of the after-harvest behavior of perishable food products and are outstanding as initiating a new botanical development.

In the years that have followed Dr. Taylor has continued his sympathetic and stimulating influence in this field of investigation, and as chief of the Bureau of Plant Industry has been largely responsible for its interpretation to the

public. The customs and practises that prevail in shipment and storage are fundamentally based on his interpretation of botanical principles as related to divided public responsibility. It is interesting to contemplate the benefits that have come to our millions of people through the loyalty and wisdom of his service.

In Powell and Fulton's reports of 1903 and in Fulton's report on the cold storage of small fruits in 1908 no literature was mentioned. The writers were in the fortunate position of having no literature that needed to be mentioned. Prior to the present century the French had contributed most to the study of the after-harvest behavior of food products, yet practically nothing that could serve as a basis for modern methods of handling them. Such studies as had been made on respiration and sugar content were confined largely to the period of ripening and were apparently stimulated by interest in the wine industry.

Bigelow, Gore and Howard in their "Studies on Apples" gave us the first fundamental investigation of after-harvest processes under cold-storage conditions, and compared the rate of respiration and the disappearance of sugar at the two temperatures of 32° and 60° F.

Morse, biochemist at the New Hampshire Experiment Station, gave a brief report in 1908, calling attention to the fact that the rate of respiration in apples was approximately doubled for each 18° F. rise in temperature. Gore followed in 1911 with his "Studies on Fruit Respiration," carried out in cooperation with the Bureau of Plant Industry—a very comprehensive report on the subject with a complete range of temperatures. He estimated that the rate of respiration was increased 2.4 times for each 18° F. rise in temperature, and found that oranges and lemons respired about half as fast as apples,

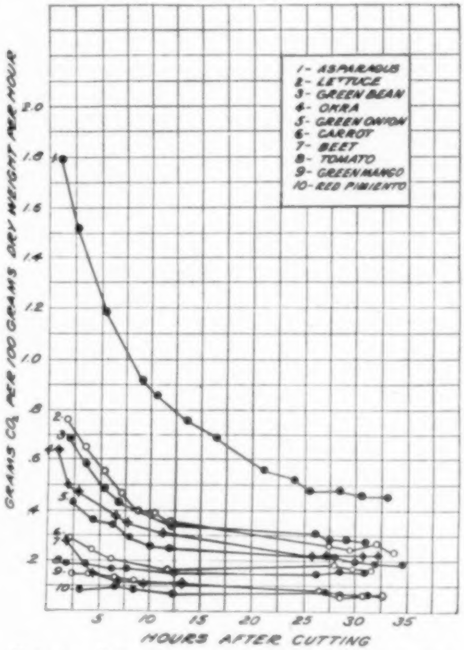


FIG. 3. CURVES SHOWING DECLINE IN RESPIRATION RATE OF FRESH VEGETABLES DURING THE A CONSTANT TEMPERATURE OF 30° C. (± 0.5). FIRST 30 HOURS AFTER CUTTING, WHEN HELD AT BENOY.

peaches and huckleberries about twice as fast and berries in general about five times as fast. These studies on respiration stand as a foundation and background for a great deal that has followed. It would be interesting to make a compilation of the publications that include Gore's work in their references.

From 1911 to the close of the world war there were few contributions to after-harvest botany. During a part of the period all efforts were centered on winning the war.

During this 7-year period Appleman published on the storage behavior of potatoes, showing that sugar accumulated at the expense of starch when the temperature fell below 38° but that this sugar could be converted back into starch by removing the potatoes to a higher temperature. He found that the

rate of respiration was accelerated by a rise in temperature and also by accumulated sugar. Hasselbring and Hawkins published on the "Respiration and Carbohydrate Transformations in Sweet Potatoes," finding a response to temperature similar to that which has been pointed out for fruits.

With the close of the world war we entered a new era in after-harvest botany. From 1918 to the present date publications have appeared thick and fast, covering various phases of diverse crops and all looking to the determination of what is actually going on in the harvested product.

Following the line of respiration and carbohydrate changes, sweet corn had first attention. In 1919 Appleman and Arthur pointed out the rapid depletion of sugar in the first 24 hours after harvest; six times as great at 86° F. as at 32° F. and three times as great at 68° as at 32° (Fig. 2). A publication the previous year by Appleman had shown that most of this loss in sugar was due to the conversion to other carbohydrates rather than to consumption in respiration. It is easy to see that after 24 hours at a high temperature sweet corn no longer deserves to be called sweet and, unfortunately, succulence and freshness disappear with the sweetness. Stevens and Higgins also published on sweet corn in 1919 and with results in agreement with those of Appleman and Arthur.

The interest in peas and beans lagged some 12 years behind that in corn, but several comprehensive publications have appeared in the past 3 years. The data recently reported by Kertesz of Geneva, N. Y., showed that with market ripe shelled peas nearly 40 per cent. and with immature peas more than 40 per cent. of the sugar was lost in the first 6 hours after harvest, if held at 77° F. The sugar was not converted into starch, as sometimes supposed, but apparently used in respiration. The loss in flavor and quality was greater than the loss in sugar. Blanching and holding at cold storage temperature greatly delayed the deterioration.

Bisson and Jones, of California, have compared the loss of sucrose in shelled and unshelled peas when held at 77° F. In 24 hours the shelled peas had lost considerably more than 50 per cent. of their sucrose whereas the unshelled ones had lost less than 30 per cent. The starch increased far more rapidly in the shelled than in the unshelled peas.

Carolus, of Virginia, has given us a similar study on green lima beans. He found that the loss of sugar was greater in the shelled than in the unshelled product, but his big contrast was between summer and cold storage temperatures; with the shelled beans showing a 69 per cent. loss in 24 hours at summer temperature and a 38 per cent. loss in cold storage. The percentage of other constituents was also reported, but the sugar content is probably the best index of quality.

There is nothing in these various reports to encourage the consumer to buy shelled peas and beans and much to justify him in demanding a product that had been as free as possible from exposure to high temperature.

With peas, corn and beans the rate of deterioration has been found to decrease with longer periods of storage. This seems to be even more strikingly true of asparagus as brought out in the work of Marjorie Benoy (Fig. 3). Note the rapid fall in the rate of respiration in the first 10 hours. With lettuce, green beans, okra and carrots the decrease is also decided.

It should also be noted that asparagus stands out preeminent in its rate of respiration after cutting. Morse, biochemist of New England, was the first to call attention to the rapid loss of sugar and quality in asparagus and the favorable

effect of low temperature. Bisson, Jones and Robbins found that at 77° F. asparagus lost 18 per cent. of reducing substances (chiefly sugars) in the first 24 hours, whereas at 33° there was no loss. The loss in sugar was thought to be partly due to transformation into cell wall material, thus contributing to the toughening of texture.

Hopkins extended Appleman's work on the potato, showing that respiration was actually greater at 32° than at 37° at lower temperatures. Upon removal from 32° to 60° respiration at first increased, and then decreased to about the normal 60° rate.

Parsnips were studied fairly early in the post-war period by Boswell of Maryland. Storage at 34° greatly increased the sugar content and improved the quality as compared with cellar storage or leaving undug. Two weeks at 34° gave a quality equivalent to that obtained in the field in two months.

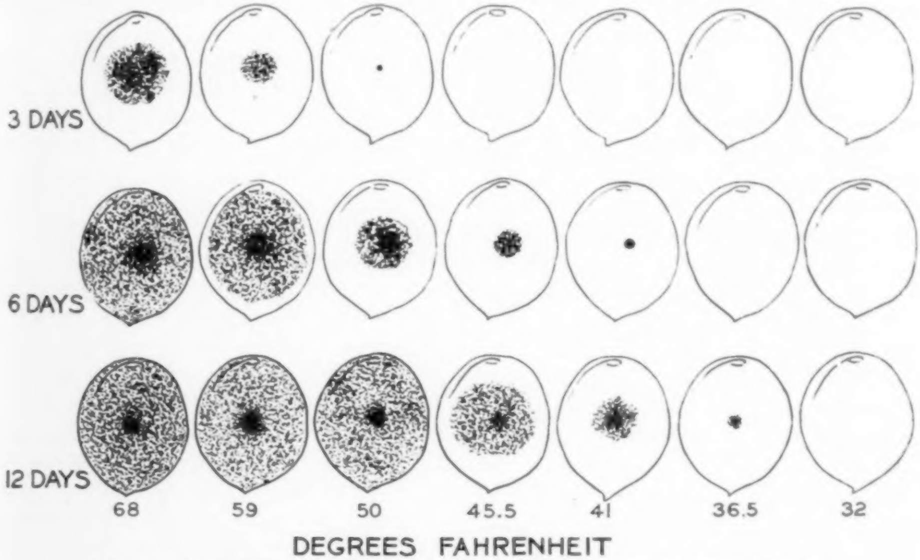


FIG. 4. EFFECT OF TEMPERATURE ON THE DEVELOPMENT OF BROWN ROT ON PEACHES.

THE SHADED AREAS INDICATE THE EXTENT OF DECAY. THE UPPER SERIES SHOWS THE SIZE OF THE ROTS AT THE VARIOUS TEMPERATURES AFTER 3 DAYS, THE SECOND SERIES AFTER 6 DAYS, AND THE THIRD SERIES AFTER 12 DAYS.

to 40° F. The higher respiration at the lower temperatures, in violation of the usual law of plant activities, was attributed to the increased concentration of sugar at those temperatures.

Wright has just published a very complete report on the physiological behavior of potatoes in storage and after storage, confirming the results of Appleman and Hopkins and showing that there is a slight increase in sugar even at 40° F. and a much greater increase

Hasselbring in 1927 reported on the behavior of carrots in storage, showing that at 39° to 40° F. they lost 43 per cent. of their sucrose in 10 weeks and at 32° to 35° F. 28 per cent. in a similar period. He found that flavor disappeared with loss of sugar content and emphasized the importance of low temperature and early consumption.

The apple and related pome fruits in keeping with their commercial importance have remained in the lead in the

after-harvest studies. The apple has been an article of export from the United States for nearly two centuries and during much of that period was practically the only export product in the perishable fruit and vegetable group. The New England export shipments of ice were accompanied by shipments of apples on a large scale, and this export trade in ice extended at one time even to India and China. The early cold storage plants were largely for apple storage, and the apple still holds the lead in the volume of export and in the volume in storage.

Magness, Diehl, Haller, Pentzer, Burroughs and others have a series of reports on the after-harvest behavior of apples, correlating the rate of softening with the rate of respiration, determining the internal atmosphere under different storage conditions and studying the effects of harvesting at different maturities. Burroughs found that the rate of respiration sometimes increased during storage.

Harding made a detailed study of this increase in respiration rate and showed the serious results of moving apples from a higher to lower temperature when at their maximum activity.

Magness and Ballard had previously shown that the respiration rate of Bartlett pears is far from constant. At 59° F. they found an acceleration from the time the fruit was picked until it was soft, yellow ripe, the highest rate being seven times the initial rate. At 37° there was no acceleration within a month and at 32° none within four months. They found that the catalase activity of the pears first increased and then decreased without a close parallelism with respiration.

Catalase has sometimes been considered a respiratory enzyme, but both Drain and Harding have failed to find any correlation between catalase activity and respiration of apples when held at a low temperature. Harding found a possible correlation at 50° F.

Carre found that there was a decrease in protopectin of apples in storage and Appleman found a similar decrease in peaches. Haller has recently reported studies showing that the softening of apples in storage is apparently due to the conversion of insoluble pectic substances, principally protopectin, into soluble form. The rate of this conversion at different temperatures was found to be in proportion to the rate of softening.

Olney found that in bananas the rate of respiration increased rapidly at the beginning of ripening and fell off gradually. Fruit held at 53° F. or lower had a relatively lower rate of respiration but failed to ripen normally.

Gerhart gave a complete report on strawberry respiration, estimating the amount of oxygen required per carload and the amount of heat produced.

Haller, Harding, Lutz and Rose have a recent report on the respiration of peaches, strawberries, lemons, oranges and grapefruit, giving special attention to the sugar and acid consumed and to the heat produced in respiration.

Both American and English investigators have emphasized the importance of parasitic and physiological diseases as confusing factors in the study of respiration and serious limiting factors in the storage life of the product. In the past sixteen years there has been a long list of publications on the parasitic organisms concerned, with data as to manner of infection, temperature response, means of control and losses involved. Eustace, Schneider-Orelli, Edgerton and Miss Ames had reported on the temperature response of a few decay organisms prior to this period.

Brooks and Cooley reported on the temperature responses of apple rot fungi in 1917. Blue mold was found to be the most serious decay organism of

stored apples. Its most rapid development occurred at about 68° to 70°, with practically none at a summer temperature of 86°, none in two weeks at 50° and none in six weeks at 32°, yet the fungus making a rapid advance at low temperatures when once established. Temperature studies were reported on seven other common decay organisms of the apple.

These same authors published later on the temperature responses of peach rot fungi (Fig. 4) and used the temperature data reported for the interpretation of later shipping tests. In a shipping period of 3 to 4 days the temperature in the top of the car was found to have about 2.5 times as great growth-producing value for peach brown rot as that in the bottom of the car.

Stevens and Wilcox gave a detailed report on the Rhizopus and Botrytis rots of strawberries as affected by temperature, humidity and other transportation and storage conditions.

Fawcett has reported temperature studies on *Phomopsis citri* and *Diplodia natalensis*, the two organisms responsible for stem end rot of citrus. Both fungi were held in check by a temperature of 6° C., 42.8° F.

Fulton and Winston and Barger and Hawkins have found that blue mold of citrus can be greatly reduced by washes containing borax or other antiseptics, and Winston has recently shown the importance of applying the treatment as soon as possible after the fruit is picked.

The most comprehensive study of a group of decay organisms that has yet been made is that in connection with sweet potato storage. It includes a series of ten or more fundamental articles, mostly by Harter and Weimer, but later ones by Lauritzen, and reports a study of the decay organisms, their respiration, their enzymes, their effect upon the respiration and carbohydrate changes in the host and the response of

FIG. 5. BLACKHEART OF POTATOES CAUSED BY EXCLUSION OF THE AIR. STEWART AND MIX.

the fungi and the host to temperature and humidity. *Rhizopus nigricans*, the most serious rot organism, was found to be a relatively low temperature Rhizopus, although having an optimum well above 70° and a minimum near 50° F. *Rhizopus tritici* was found to produce a powerful pectinase enzyme capable of affecting complete maceration of raw potato disks.

With high humidity and high temperature sweet potato wounds were corked over in 4 to 6 days, thus furnishing protection from fungous attack. With a humidity of 72 to 84 per cent. there was nearly 100 per cent. of infection with Rhizopus, whereas with a humidity of 94 to 98 per cent. infection was largely prevented. This is in violation of the usual laws in regard to infection, and the exception to the rule is due to the host response. The most rapid healing was at about 90° F., but cork formation occurred at as low temperature as 67.1°.

The effect of temperature and humidity upon suberization and wound-periderm formation has been followed in detail by Artschwager and Starrett.

Lauritzen found that holding sweet potatoes at temperatures below 48° F. for as long as 15 days resulted in increased susceptibility to decay.

Weiss, Lauritzen and Brierly have recently reported on the relation of tem-

perature and humidity to suberization and wound-periderm formation in the Irish potato, and Smith of Cornell has a publication covering the same subject. Wound periderm formation that required 3 or 4 days at 70° F. required more than 8 days at 50° F. Humidity was not ordinarily a limiting factor.

Lauritzen has recently published on storage and transit diseases of carrots, peppers and beans, and Tompkins and Pack on the storage decay of sugar beets.

In the fungous diseases of stored products it can be generally assumed that lowering the temperature will decrease the activity, but the work of Berry and Diehl shows that in the freezing preservation of fruits in sealed packages a storage temperature of 15° F. results in a much greater kill of microorganisms than a temperature of −5° F. However, the greater kill at the higher temperature is attributed to the greater accumulation of carbon dioxide.

The field of physiological diseases has received even more attention than that of the parasitic diseases, especially from foreign investigators. In some respects it is more difficult and controversial and perhaps for that reason a more enticing field. In contrast with diseases that are due to fungi many of the physiological diseases are produced only at low temperatures.

Potato blackheart is one of the diseases that received early attention (Fig. 5). When potatoes were held in storage or shipped in large volume the interior of the potato was later found to have turned black. Studies on the cause were in progress prior to the post-war period we have been considering. In 1915, Bartholomew reported the trouble to be due to holding the potatoes at high temperatures, such as 100° F., or above, and considered that the real cause was probably a lack of oxygen in the tissues. Stewart and Mix followed with a report in 1917, giving definite proof that the disease was due to a lack of oxygen and not to an accumulation of carbon dioxide, and showed that by means of a reduced oxygen supply and prolonged exposure, the disease could be produced at temperatures as low as 35.6° F. Bennett and Bartholomew reported a very complete study in 1924, confirming the work of Stewart and Mix and showing that, while in general longer periods of exposure were required at low than at high temperatures, the injury could be produced more quickly at a temperature of 32° than at 41°, apparently because of the increased sugar content and resulting higher rate of respiration below 41°.

But the apple is in the lead in the variety of its physiological storage troubles and outstandingly in the lead in the literature devoted to them.

The condition of fruit at the time of harvest has been repeatedly emphasized as modifying its later storage behavior. Various Plant Industry workers have pointed out the importance of full maturity in the prevention of apple scald. Brooks, Fisher and Harley found that water core of apples was greatly increased by over-maturity and high temperature, but that mild forms of the disease were likely to disappear in storage. They reported that the occurrence of bitter pit in storage was much worse on fruit that was forced late in the season and worse on early-picked fruit than on late-picked. Carne, of Australia, has recently reported that the storage development of this disease is almost entirely determined by maturity.

The difficulties in regard to apple scald in a rapidly expanding cold storage industry was apparently an important factor in initiating the early studies of Powell, Fulton and Gore. It was suspected that low temperature was the cause of scald, but Powell and Fulton showed that more scald developed at 36°

FIG. 6. GRIMES GOLDEN APPLES AFTER STORAGE, SHOWING THE CONTROL OF SCALD WITH OILED WRAPPERS.

than at 32°. Storage houses continued to receive much of the blame for scald in spite of the fact that later studies emphasized the importance of maturity in the fruit and the benefits from immediate as compared with delayed storage.

Following the world war, Plant Industry workers published a series of articles showing that scald responded to temperature in accordance with other plant activities and increased in seriousness or at least in rapidity of development from 32° up to 70° or 75°. They found it was decreased rather than increased by an accumulation of carbon dioxide, that it was not due to a lack of oxygen and not greatly influenced by humidity, yet could be prevented by aeration or by packing the fruit in oiled wrappers or shredded oiled paper (Fig. 6). This raised the question as to what harmful substance the apples could be producing that could be carried away by air currents or eliminated by the presence of oil. There was no information in this field, and the problem was taken to Power and Chesnut, of the Bureau of Chemistry. Dr. Power was a world authority on odorous plant products. They started a study on the odorous constituents of the apple and found them to consist of various esters and in addition a considerable proportion of acetaldehyde, which they suggested might be a factor in the production of apple scald. Acetaldehyde was known to be extremely irritating to human respiration and seemed to be just the thing to cause trouble in the plant metabolism, but it has proved a difficult culprit to catch in the act. In the last 10 or 12 years it has been chased up one alley and down another but never quite completely proven guilty.

Harley and Fisher found a close correlation between the development of scald and breakdown in pears and the accumulation of acetaldehyde in the tis-

FIG. 7. SOFT SCALD ON JONATHAN APPLE.

sue. Thomas in England concluded that the accumulation of acetaldehyde in pear tissue was the result of pear breakdown rather than the cause. He emphasized the importance of the oxygen-carbon dioxide ratio as a determining factor in the occurrence of acetaldehyde and alcohol in the fruit tissues. Gerhardt and Ezell have recently found evidence that an increase in the alcohol and acetaldehyde content of pear tissue may be taken as an indicator of objectionable physiological conditions that will soon follow with continued cold storage. Various studies on acetaldehyde and on alcohol acetaldehyde ratios are in progress in England, America, Japan, Italy and Australia. Some English investigators are pointing out the dangers of acetaldehyde, while others are suggesting that its introduction into the storage air may be a possible means of controlling decay.

Nelson, of Michigan, has recently published on suboxidation and low temperature diseases of various fruits and vegetables.

Internal browning is a physiological storage disease of the apple particularly common on the Yellow Newtown of the Pajaro Valley, California. It has been shown by Ballard, Magness and Hawkins, and by Overholser, Winkler and Jacob that the disease can be largely prevented by holding the fruit at 38° to 40° instead of at 32°. The latter group of workers found that the disease could be greatly reduced by ventilation.

Soft scald is a sporadic physiological disease of apples, producing most peculiar patterns and formerly classed as frost injury (Fig. 7). The disease has been studied by Magness and Burroughs; Brooks, Cooley and Fisher; Fisher and Harley; Plagge and Maney; and by various workers in England, New Zealand and Australia. It is recognized as a low temperature disease largely prevented by storing at 35° to 38° or above and as decreased by ventilation and due to a lack of oxygen; yet very curiously can be greatly decreased by short-period exposures to carbon dioxide or to high temperatures before placing in storage.

Soggy breakdown is a companion disease to soft scald and due to similar causes. Plagge, Maney and Harding have studied the disease, also English workers.

The storage life of oranges and grapefruit is limited by the development of a pitting of the peel (Fig. 8). The disease is much worse at 36° and 40° than at 32° and storage at 45° to 50° or at a higher temperature almost entirely

FIG. 8. PITTING OF GRAPEFRUIT.

prevents the trouble. These higher temperatures, however, may result in serious decay.

The work that has been done on these different physiological diseases has given us more or less satisfactory remedies, but the real cause is still to be found.

What is happening in grapefruit at 40° but not at 50° and what in apples at 32° but not at 38°? These are most interesting questions, but the answer is not yet in sight. A complete solution of the problems might bring about great changes in storage practises. The functional and old-age diseases of fruits and vegetables are far from being well understood. In this they have a parallel in the functional and old-age diseases of the human race.

Many attempts have been made in recent studies to obtain a better index of keeping quality. There is a long list of American publications on the effect of nitrate fertilizer on keeping quality. Archbold, of England, finds that high nitrogen value and low acidity in apples is associated with high rate of respiration. Plagge and Gerhardt, of Iowa, found that the greater the acid loss in apples the better the keeping quality. Dutoit and Reyneke, of South Africa, think they have the secret of keeping quality in a high ratio of active acid to total acid. Various writers emphasize the importance of acid in the respiratory metabolism of the fruit.

The English investigators have taken the lead of late in the study of physiological diseases and in the study of storage atmospheres in general. They not only have done excellent work and a great deal of it but they keep the public advised as to what they are doing. Our own press has frequent quotations from the English in regard to discoveries that in some instances should be largely credited to American investigators, yet the publicity has come from England and the English receive the whole credit in the minds of the public.

Here is a much-quoted statement abbreviated from the presidential address of Sir William Hardy before the British Association of Refrigeration: "A stream of air which has passed over apples contains subtle emanations which cause potatoes not to sprout or to produce misshapen dwarf sprouts and cause bananas and unripe apples to ripen more rapidly. Only elderly apples give off these emanations." The discoverer of these relationships was O. H. Elmer, a plant pathologist in Kansas, and his results were published in *Science* in 1932, but it was left to Hardy in England to use the information in a manner to attract the attention of the public to the scientific work in progress.

The English investigations after the war were first directed to a study of brown heart of apples. The Australian shipments often arrived in England with a high percentage of this trouble. It was found to be due to the high percentage of carbon dioxide that developed in the hold of the ship as a result of slow cooling. A remedy was found in better ventilation and more rapid cooling.

They followed with elaborate tests as to just the percentage of carbon dioxide the apples would stand at different temperatures, and the results of their investigations are now in practical application. According to *Food Manufacture* of London, nearly one fifth of the apples in England are now held in gas storage with the prospect that this method of storage is to be rapidly extended. With Branley's Seedling apples the best results have been obtained at about 41° F. with 10 to 15 per cent. carbon dioxide and 10 per cent. of oxygen in the atmosphere. The results under these conditions were one and one half times better than in ordinary cold storage at 34°. In later tests with Lane's Prince Albert apples better results have been obtained with a storage

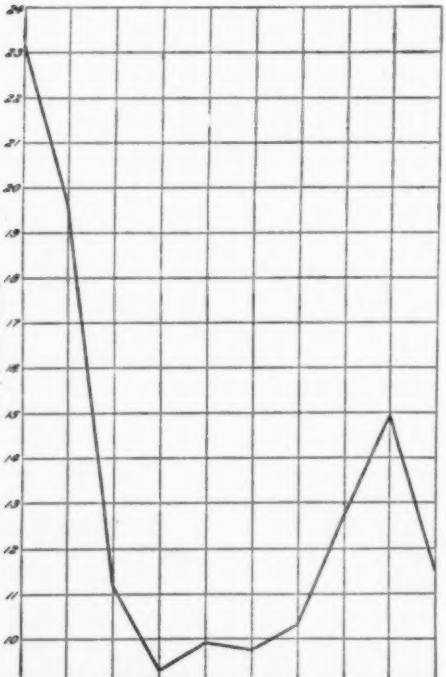


FIG. 9. ESTIMATED LOSSES FROM STORAGE ROTS OF SWEET POTATOES IN THE UNITED STATES, 1920–1929. STEVENS.

atmosphere containing but 5 per cent. of carbon dioxide and 2.5 per cent. of oxygen.

The idea of gas storage is old. Berard, a Frenchman, reported gas storage experiments more than a century ago. The Reverend Benj. M. Nyce, of Decatur, Ind., who in 1856 received a patent on his ice storage house and offers of large sums in royalties, abandoned the idea of ventilation and endeavored to accumulate atmosphere of carbon dioxide in the storage room. Gore found that carbon dioxide could be used to ripen persimmons and remove their astringent taste. In 1913 Hill, of Cornell University, published on the respiration of fruits in various gases and pointed out the danger of lack of ventilation in storage. These dangers have been further emphasized by later studies, yet the idea of gas storage has often expressed itself in rather wild schemes, one of the wildest of which was the recent citrus experiment at Howey-in-the Hills, Fla. Each of three large metal tanks was filled with three carloads of citrus fruit, sealed, the air partially or entirely displaced by other gases and the tanks left for months in the hot sun with the expectation that the fruit would be preserved in its fresh condition. The line of reasoning seemed to be that if the fruit could not get air it could not spoil. It must have got some air.

Gas storage of the English type does not seem likely to become popular in this country, at least in the near future. It does not fit well into our established customs. We do have gas storage in a mild form in the wrappers and in the waxes that are used on some of our fruits. It has been shown that these bring about an increase in the carbon dioxide and a decrease in the oxygen content of the internal atmosphere of the fruit.

Some attention has been given recently to the possibility of short-period gas storage as a preventive for the deterioration and losses that result from failure to secure rapid cooling of the harvested product. It has been found that placing a few hundred pounds of solid carbon dioxide in the car of freshly loaded fruit will result in sufficient carbon dioxide gas to check both ripening and decay to a degree that is difficult to secure with refrigeration alone, and that with conservative use of the treatment as a supplement to the usual refrigeration, no injury to the product need result. Miller has found that treatments of this character tend to preserve the sweetness and freshness of corn and peas.

Thornton has shown that exposure to carbon dioxide in the presence of oxy-

gen results in a reduction in the acidity of the plant tissue, and with some products in a marked increase in the rate of respiration and with others in a marked decrease.

Recent literature contains studies on the effect of ethylene upon sugar changes and rate of respiration when used as a coloring or ripening agent; studies on the effect of freezing upon respiration and catalase activity; studies on the changes in the waxlike coating of apples during storage; studies on the composition and physiology of various products in relation to satisfactory canning and freezing procedure; and papers dealing with various other phases of after-harvest botany that can not be followed in detail at this time.

In a presidential address before the Washington Botanical Society 20 years ago Dr. W. W. Stockberger[1] discussed the subject: "The Social Obligations of the Botanist." The burden of his talk was to the effect that the botanist's efforts should not be dominated solely by his interest in plant life but rather by his desire to make botany of service to mankind; that he must not overlook his obligation to return value to society in keeping with and surpassing the support he was receiving from the public.

Measured by this standard, after-harvest botany can give a good account of itself in the time that has elapsed since the above address. The business of supplying perishable food products to our millions of people rests upon an entirely different foundation to-day than it did 20 or even 15 years ago. It is true that it has long been known that apples keep better in a cool cellar than in a warm one and that certain rule of thumb methods should be followed in the handling of various food products. This type of information may have been fairly satisfactory for handling farm products for home consumption, but it formed no reliable foundation for the new era of mechanical refrigeration, long distance shipments and divided responsibility. The question is no longer as to whether the product should be cooled but that of how cold, how quickly cooled and how much ventilation, and if spoilage occurs who was to blame and what the significance of this or that harvesting, shipping or storage condition. Such questions can only be answered by scientific study of the various factors involved, and in the absence of reliable information the problems are likely to be settled by costly court procedure with the consumer ultimately paying for the cost of the settlement as well as for the loss of the food. When the laws underlying a trouble have been discovered so that responsibility can be definitely placed the trouble is likely to be largely eliminated.

Here is a figure from data compiled by N. E. Stevens, showing the effect upon sweet potato storage of the research work previously outlined (Fig. 9). Note the precipitous drop in stor-

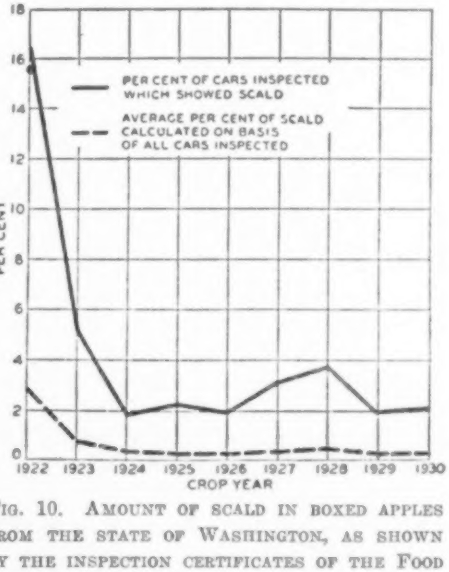


FIG. 10. AMOUNT OF SCALD IN BOXED APPLES FROM THE STATE OF WASHINGTON, AS SHOWN BY THE INSPECTION CERTIFICATES OF THE FOOD PRODUCTS INSPECTION SERVICE, U. S. DEPARTMENT OF AGRICULTURE. STEVENS.

[1] *Science*, n.s., 39: 733–743, 1914.

age rots at the time the information was being made available. The consumer could almost be given four potatoes for the price he formerly paid for three, and in addition to this, the work resulted in greatly extending the season in which sweet potatoes were available.

Here is another figure from data compiled by the same author (Fig. 10). It shows the effect of the development of the oiled wrapper upon the occurrence of scald on the apples that were passing into the channels of trade. The first extensive use of oiled wraps was in 1923 and they came into almost universal use on boxed apples in 1924. This chart shows the results on apples from Washington State, where the treatment was speedily put into practise, but oiled paper is now used as a preventive for scald in Canada, England, Switzerland, Australia, New Zealand and South Africa as well as in the different sections of the United States.

Rose and Lutz have recently cleared up a serious controversy in regard to bruising and freezing injury in car-lot shipments and found a remedy that promises to eliminate the trouble.

Items like these could be greatly multiplied. Every study that has been mentioned in the present discussion and many that have been omitted have had their beneficial effects in one or more phases of the industry. Various methods of precooling have been developed, market surveys and studies have been made, market pathologists located in the large cities, receiving point and shipping point inspection established, and above all out from the office of the chief of the Bureau of Plant Industry has gone a continuous stream of letters giving carefully balanced decisions, based on intimate knowledge of the findings of research and furnishing a powerful directing hand in the gradual adjustment of industry.

Losses have not been eliminated, however. Here are some figures showing the average claim per car paid by the American Railways in 1932.

Product	Loss and damage per car
Tomatoes	$24.89
Lettuce	19.44
Carrots	18.35
Watermelons	17.24
Cantaloupes	17.18
Plums and prunes	16.16
Grapes	14.80
Asparagus	13.31
Peaches	11.87
Pears	10.48
Oranges	6.20
Apples	5.88
Onions	4.37
Potatoes (sweet)	3.27
Potatoes (white)	1.05

Perhaps the claim on eggs of $3.95 a car and that on glass of $1.07 a car should have been included with this list. Why need the loss on tomatoes be more than 6 times that on eggs and that on sweet potatoes 3 times and that on apples 5 times as great as the loss on glass? Either the response of the plant material is not sufficiently known or else the available knowledge has not been properly standardized and applied.

The total claims paid by the American Railways on freight shipments of fresh fruits and vegetables in 1932 was $7,203,145, almost equalling that paid on all other commodities, although representing but 3 per cent. of the total cars handled. These figures do not include the losses in shipment by express nor those by boat and truck, nor do they include the losses in storage and in the wholesale and retail markets. The total would run into an enormous figure.

These losses, however, are being reduced. With allowance made for changes in volume of traffic the freight railway claims on fresh fruits and vegetables were 18 per cent. lower in 1932 than in 1930, a reduction of more than $2,000,000. This item in itself represents the removal of a considerable bar-

rier between the producer and consumer.

It might at first seem that the prevention of loss in a harvested product would be of benefit only to the party that carried the responsibility at the time the loss was likely to occur, but the charge for market operations is based on a supposed loss that must be passed along in the cost to the consumer. I was very much interested a few years ago in a remark by one of our largest brokers and exporters in regard to a serious and confusing disease of apples. He said in effect: "Professionally and ethically I am very greatly interested in the control of this disease, but insofar as my own business and profits are concerned, I have no interest whatever." To him the disease was only an additional hazard that made the failure of his less experienced competitor more certain. The consumer must ultimately pay for the spoilage either in the quality or cost of the product.

The botanical foundation and background that has been developed for shipping and marketing operations has brought the consumer many and varied benefits in character and quality of food.

It may be worth while raising the question whether the consumer has been given the opportunity of knowing that he has received benefits and more particularly as to whether he has been furnished with information in a form that will enable him to use the available botanical knowledge in the purchase and care of perishable food products. It has become the firm conviction of the dealer and tradesman that the consumer buys entirely with his eyes. I have heard it repeatedly from dealers that a cent's worth or less of shredded paper of the proper color (a by-product of apple scald treatment) when scattered over the top of a package of fruit will result in the consumer paying 25 cents to 50 cents premium for the package when displayed in comparison with undecorated fruit. To the extent to which this is true we can hardly say that we are very far removed from the days when the pioneers traded glass beads to the Indians in exchange for costly furs.

Has the botanist done his duty in seeing that information has been furnished to the consumer in an interesting and usable form? Should not our colleges and high schools give enough attention to the laws governing the behavior of harvested products to give the student an attitude of further inquiry? Is there any reason why the magazines that carry recipes for cooking plant products should not also carry short articles in regard to their selection and care? If we are to have dated coffee, why not dated vegetables or something equivalent?

It would seem that a better understanding on the part of the consumer of the products with which he is supplied might result in decided benefits both to himself and to the agricultural industry as well.

THE CHEMISTRY OF THE HORMONES FROM A STRUCTURAL STANDPOINT[1]

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In the present review we shall attempt to evaluate what we actually know of the chemical structure of the hormones. The immense amount of activity in the endocrine field is bringing many hitherto inaccessible hormones within the scope of attack of the chemist, and it may be interesting to sum up at this time just what has been accomplished to date on the hormones from a structural standpoint. In so doing we may appreciate more fully what is yet to be accomplished.

It should be realized that very little can be done from a structural standpoint until the hormone is isolated in the pure chemical form. This can not be overestimated. It is true that with highly active but impure preparations one can obtain some idea as to the stability of the compound and some suspicions as to what types of groupings are present, but the real chemical work must rest on isolation of the hormone in crystalline form.

In the chemical attack on a hormone, isolation is, therefore, the first goal. The question of the chemical structure follows, intermingled with hopes of synthesis, for it is always the hope of the chemist to be able to synthesize within the chemical laboratory what is found in nature. However, the chemical attack is not finished with the isolation and synthesis of a hormone. There still remains the very intriguing problem of studying what particular groups in the molecule are responsible for its physiological action, and the synthesis of other compounds of analogous structure in the attempt to find a synthetic product of somewhat similar physiological action but more fitted for a particular clinical use. This is well exemplified by the study of epinephrine and the synthesis of epinephrine-like compounds, and the study of derivatives of thyroxine.

Another interesting phase of the chemistry of the hormones is the study of the relationship of a hormone to other physiologically significant compounds from a structural standpoint. Often this leads to an appreciation of underlying physiological relationships not otherwise appreciated. The importance of this has been particularly brought out in the investigations of the female sex hormone. This structural study has brought out the relationship of this hormone to the male sex hormone, cholesterol, cholic acid, ergosterol, Vitamin D, certain carcinogenic substances, certain cardiac glucosides (strophanthin) and even to certain alkaloids. Closely related to this aspect of the work is the study of the precursors of the hormone and their final metabolic fate.

Of the host of hormones that occur in the body, so far, only two have been synthesized in the laboratory. Four more have been isolated in crystalline form, but of these four we have a clear insight into the structures of only two of them. It is, therefore, quite apparent that the field of the chemistry of the hormones is in reality quite in its infancy. A great number of the hormones

[1] Presented in the symposium, "A Survey and Evaluation of the Present Status of Endocrine Investigation," held by the Medical Sciences Section of the American Association for the Advancement of Science, at the University of California, June 19, 1934.

which are now recognized solely by their physiological action remain to be isolated in pure form, their structures to be elucidated, and finally to be synthesized. There must be, indeed, a vast number that still remain to be recognized. It seems to me that it would be presumptuous for us to think that we recognize all the hormones at the present time, even as it was some years ago to think that the vitamins could be summed up in "A, B, C."

The two hormones to which I refer as being the only ones that have fallen under the synthetic attack of the chemist are, of course, epinephrine and thyroxine. Their synthesis represents the high point of the application of organic chemistry to the endocrines. The beautiful work that led to their isolation, their proof of structure and their synthesis serves as a stimulus for the attack on the other hormones.

The working out of the structure and synthesis of epinephrine soon followed its isolation in crystalline form. The isolation itself followed surprisingly quickly after the demonstration by Oliver and Schaeffer in 1894 that the adrenal gland contained a blood pressure raising principle. Abel succeeded in isolating a derivative of the hormone responsible for this action in 1901, and shortly thereafter Takamine obtained the free base in crystalline form. The structure of the hormone was elucidated through the joint efforts of many workers in the field within a couple of years and found to be as shown in Fig. 1.

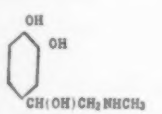
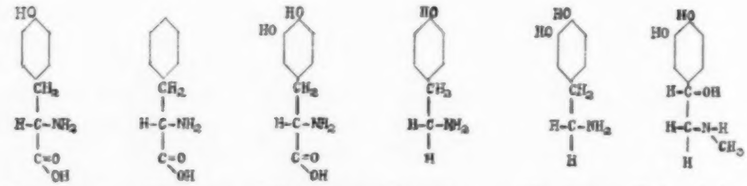


FIG. 1

It was finally synthesized by Stolz and by Dakin. The synthetic compound was, of course, the optically inactive form. The resolution worked out by Flächer led to the preparation of both the levo and the dextro epinephrine, and the levo epinephrine was found to be identical with the naturally occurring hormone. As is well known, the levorotatory epinephrine is 14 times as active as the dextro isomer, which emphasizes the importance of spatial configuration in connection with the hormones. This successful application of organic chemistry to the endocrines naturally directed much attention to this most interesting field and stimulated work on the other hormones.

Knowledge of the structure of epinephrine also initiated synthetic work in compounds closely allied to it in structure in order to find out which groupings are responsible for the activity of the compound. From the work of Barger and Dale it soon became apparent that the presence of the hydroxyl groups on the benzene ring is extremely important for the blood pressure raising action and that the absence of these groups results in a great reduction in activity. The presence of the alcoholic hydroxyl group on the side chain is also necessary for the high degree of activity of epinephrine, but it is not nearly so important as the phenolic groupings. I think, though, that it is fair to say that the chemist has so far failed to synthesize a more active pressor compound than *l*-epinephrine.

As I mentioned, the study of the precursors of a hormone is of much interest. In the case of epinephrine its structure immediately calls to mind the possible relationship to the amino acids, phenylalanine, tyrosine, dihydroxyphenylalanine and their decarboxylation products (Fig. 2). It is also interesting in this connection that the skin contains an enzyme "dopase" which converts dihydroxyphenylalanine to melanin, a deeply pigmented compound, and that there may be some relationship of this to the pigmentation or bronzing of the skin that occurs in Addison's disease.



Tyrosine | Phenylalanine | Dihydroxyphenylalanine | Tyramine | Dihydroxyphenylethylamine | Epinephrine

FIG. 2

It has been suggested that a precursor of epinephrine, possibly dihydroxyphenylalanine, is not used up properly by the diseased gland and upon its accumulation is acted upon by this enzyme "dopase" and is laid down in the skin as this pigment.

The evolution of our knowledge of the hormone of the thyroid proceeded at a much slower pace. An interval of 19 years elapsed between the separation of a quite potent fraction of the thyroid and the isolation of thyroxine by Kendall in 1914. It then required 12 years before its structure was finally worked out. From the beautiful work of Harington and Barger, we now know that thyroxine has the structure shown in Fig. 3. In an amazingly short period of

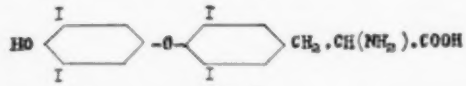


FIG. 3

time Harington and Barger accomplished its synthesis. The synthetic product required resolution for the final step in producing a compound identical with the naturally occurring hormone. Again it turned out that the levo or naturally occurring form was more active than the optical antipode.

In considering the structural relationship of thyroxine and other substances in the body, the similarity in structure with tyrosine was rather suggestive that this amino acid may also be the precursor of thyroxine. Furthermore, diiodotyrosine has been isolated from the thyroid gland.

It is also of much interest that Harington and coworkers have found that diiodothyronine is effective by mouth in treating myxoedema and that it seems to lead less likely to too high a basal metabolic rate upon over-dosage. This is an excellent example of what I meant by the possibilities in a study of compounds closely related in structure to a hormone of producing a substance that may have a certain advantage from a particular clinical standpoint.

These two hormones represent then the only ones of which we know conclusively the chemical structure. We do indeed have a long way to go, but the path is such an interesting one that we do not notice the time consumed in our gradual progress.

I said earlier that four other hormones had been isolated in crystalline form in addition to epinephrine and thyroxine, and that the structures of two of these were fairly well understood. These two are the female and male sex hormones. The structure of theelin, the so-called female sex hormone isolated by Doisy and by Butenandt in 1929, is quite well worked out. The conception of its structure by Butenandt rested on certain developments in the study of cholesterol. When the relationship of theelin to cholesterol was surmised, and when the general structure of cholesterol was realized, the possible structure of theelin became evident. It had earlier

been thought that the structure of cholesterol was that shown in Fig. 4.

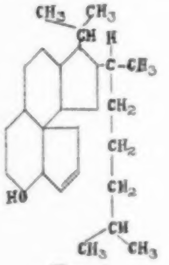


Fig. 4

But Rosenheim and King pointed out that a structure of the chrysene type would not only explain all that the above structure would, but would also explain certain reactions of cholesterol that this first structure would not. Windaus and Wieland quickly saw the truth in this suggestion and, by reinterpretation of old data and the obtaining of new, worked out a structure of cholesterol which seems to be the true one. It is rather generally agreed that the structure of cholesterol is as seen in Fig. 5.

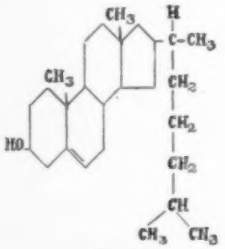


Fig. 5

With keen perception Butenandt realized the relationship in structure between theelin and cholesterol, and through clever deductions suggested the

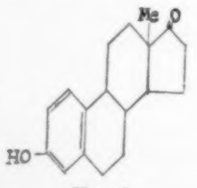


Fig. 6

formula in Fig. 6 for the female sex hormone. Later he presented chemical evidence in favor of this structure. It must be pointed out, however, that this structure is not entirely proven; there are still points about it that must be ascertained. This work is going forward rapidly in the laboratories of Doisy, Marrian and Butenandt, and it will probably not be long before the entire story of the chemical structure of this important compound will be revealed.

Theelol, the trihydroxy oestrogenic compound, isolated from pregnancy urine by Marrian and by Doisy, is closely related in structure to theelin, and in fact Butenandt has been able to convert theelol to theelin in the laboratory by a dehydration reaction. If the structure of theelin is that which we have just indicated, theelol must then have the structure shown in Fig. 7.

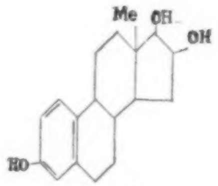


Fig. 7

The male sex hormone is, interestingly enough, apparently closely related in structure to theelin. Butenandt has suggested the structure for the compound he has isolated in Fig. 8. This,

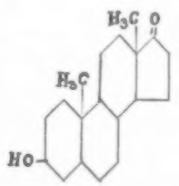


Fig. 8

of course, remains to be confirmed by conclusive chemical proof. The work on this compound is extremely difficult because of the paucity of material; for example, 25,000 liters of male urine

were required to produce only 15 mg of the crystalline hormone.[2]

The relationship chemically and physiologically between Butenandt's hormone and that of Koch and of McCullagh, neither of which, however, has been isolated in crystalline form, and the relationship between the latter two, is not entirely clear. Koch has recently presented some evidence that his compound prepared from bulls' testes may be different from that of McCullagh prepared from male urine.

There have also been isolated certain oestrogenic compounds from the urine of other animals and from plant sources and also certain substances isomeric with theelin whose chemistry is still to be worked out.

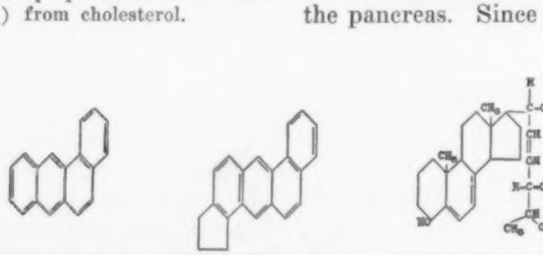
Another most interesting turn of events that followed closely the realization of the structure of theelin and cholesterol is the fact that certain carcinogenic substances found in coal tar by Kennaway and coworkers were, peculiarly enough, related to these in structure. The synthesis of other carcinogenic substances and the testing of them for oestrogenic activity and *vice versa* soon followed. It has been shown by the work of Cook, Dodds and coworkers in England that certain of these substances, such as 1 : 2 benzanthracene and 5 : 6 cyclopenteno–1 : 2–benzanthracene, possess both carcinogenic and oestrogenic activity.

[2] Since this paper was submitted Ruzicka has achieved the artificial preparation of this hormone (Androsteron) from cholesterol.

This work has also led to the surprising finding, based again on structural relationships, that Vitamin D derived from irradiated ergosterol also possesses some oestrogenic activity. These studies of Cook and Dodds have also led to the preparation of other synthetic compounds of a high order of oestrogenic activity comparable with that of the hormones themselves. The working out of the underlying physiological and possibly pathological relationships based on these findings will no doubt lead to very significant results. I can not believe that the behaviors just mentioned can be merely accidental manifestations of metabolically unrelated compounds.

The other two hormones that exist in crystalline form but whose structures are as yet unknown, are insulin and cortin. Kendall recently announced the isolation of a crystalline compound from the adrenal cortex of the empirical formula $C_{20}H_{30}O_5$. Wintersteiner, Pfiffner and Vars have also reported results which indicate that cortin is a non-nitrogenous compound. There is little use in discussing the chemical properties of cortin at the present time, for certainly more definite information concerning its structure will soon be available from a study of the crystalline compound.

The isolation of insulin in crystalline form by Abel followed within 5 years the announcement of Banting and Best of the preparation of active extracts of the pancreas. Since that time intensive



1 : 2–benzanthracene 5 : 6–cyclopenteno–1 : 2–benzanthracene Ergosterol

FIG. 9

work has gone forward in many laboratories on the crystalline insulin and many interesting facts have been brought forth. Yet in all frankness, we must admit that we know practically nothing of the structure of insulin. It is true that certain amino acids have been isolated from the crystalline material, but this has given little insight as to structure except to confirm the idea that insulin is a protein substance. The isolation of these amino acids, however, was necessary because at the time that that work was undertaken there was talk of a peculiar sulfur linkage and of the possibility of there being an unusual guanido compound present. Further, it was not known whether the imidazole reaction was due to histidine or the phenolic reaction due to tyrosine. The isolation in crystalline form of cystine and tyrosine, arginine and histidine was therefore significant. The study of the nitrogen distribution by Wintersteiner was also quite necessary but revealed no unusual distribution. A fact that is probably of the greatest significance is strangely a negative one, and that is, that no one has so far isolated from insulin any constituent other than those which can be found in other proteins.

It is therefore quite evident that there is not one iota of proof as yet for the existence of a prosthetic grouping in insulin. The chemist would like to believe that there does exist such a group, for it would be in its isolation or in its identification in the molecule that the hope of the chemist lies. On the other hand, I must equally emphasize that no evidence has been presented that rules out the existence of such a prosthetic grouping. The point I wish to make is that discussion concerning an active grouping rests purely on hypothesis, and evidence for it remains for future research to bring forth, a fact emphasized by Jensen in his recent excellent review of the "Chemistry of Insulin."

The importance that Abel, Geiling and coworkers attached to the presence of sulfur in the crystalline product has been entirely justified by subsequent research. The sulfur is a vulnerable point in the structure of insulin, and, as we have pointed out elsewhere, no one has modified or changed the sulfur of insulin without affecting potency, although it may be true that insulin can be destroyed without affecting its sulfur. The fact that insulin can be destroyed without affecting the sulfur does not detract from the fact that the disulfide is necessary to the action of insulin. There may well be other groups necessary to the insulin action.

There is another point I would like to mention in connection with the chemistry of insulin and that is the heat precipitation reaction. As far as we know, this is the only reaction characteristic of insulin material. When insulin is heated in dilute acid a precipitate is formed which is inactive but upon treating with dilute alkali it dissolves and is once again active. It furthermore regains its solubility in dilute acid and the entire process can be repeated. Inactivation by a variety of agents, such as acids, alkali and reducing agents, causes as well the heat precipitation reaction to disappear. The fact that activity and heat precipitation seemed to accompany one another led us to believe for a time that the same groupings were involved in both behaviors. However, we have obtained a fraction of insulin still heat precipitable but inactive, which of course makes the above hypothesis untenable. Of particular significance in connection with the heat precipitation is the fact that the regenerated insulin is a changed insulin having certain different physical properties. It gives one hope that one may be able to further modify insulin without destroying its hypoglycemic action and possibly to modify it to such an extent that it will

be changed enough to become resistant to proteolytic enzymes and thereby open the possibility of mouth administration.

Many other hormones have been highly purified but have as yet resisted the efforts that have been made to crystallize them. Much has been done on the hormones of the post pituitary, the parathyroid hormone, secretin, progestin[3] and the gonadotropic hormone excreted during pregnancy. All these exist in quite highly purified form. Of the hormones I have just mentioned all of them except progestin seem to be of protein or polypeptide-like structure. There is also the host of hormones which are known mainly through their physiological behavior, but knowledge of their chemistry is most meager. A discussion of their structural chemistry would be unprofitable at the present moment as so little is known of their actual chemistry. I would, however, like to say a few words about the present status of our knowledge of the chemistry of the post-pituitary hormones.

The physiological action of the extracts of the post pituitary have long been recognized and methods of assay have been available for many years, yet the compound or compounds responsible for the physiological activities have defied efforts at their isolation. The pioneer isolation work was here again due to Abel. It has been generally recognized that the melanophore principle is a separate one, but there is still a division of opinion as to whether the pressor, antidiuretic and oxytocic activities are due to a single mother substance or whether there exist separate pressor and oxytocic principles. Abel is still in favor of his unitarian hypothesis, while Kamm is the main proponent of the multiple theory. Kamm and coworkers have succeeded in isolating preparations of exceedingly high pressor but practically no oxytocic activity, which he called "pitressin," and preparations of high oxytocic activity with only a small amount of pressor activity, which he called "pitocin." These preparations are the most potent that have so far been isolated. The decision as to whether or not these compounds exist in the gland as separate principles or together as a mother substance must await future research. It might be well to allow the question to rest until the substances are isolated in crystalline form and their structures worked out, for then it can be ascertained whether or not they could have been linked together.

In working on the chemistry of these pressor and oxytocic principles we have recently obtained evidence which we feel clearly demonstrates that sulfur in the disulfide form is present in both the hormones, pitressin and pitocin.

Kamm and Grote were good enough to place in our hands a series of preparations of pitressin and pitocin of varying degrees of potency which enabled us to study their composition in order to detect if possible any distinguishing chemical properties between these two principles. We wished to find out if there were any characteristic chemical changes with increasing concentration of the active principles which might be useful in following, from a chemical standpoint, further attempts at their isolation. As a preliminary attack along these lines with Messrs. Sealock and Sifferd we have determined the sulfur, nitrogen, cystine, tyrosine, arginine and histidine contents of the various fractions. A striking difference was found in the cystine content of the highly purified preparations of pitressin and pitocin as determined by the Sullivan method. For example, a sample of pitocin possessing 500 units of oxytocic activity per mg contained 3.05 per cent. sulfur and had a cystine value of 8.96 per cent., whereas a sample of pitressin containing 200 units of pressor

[3] Allen and Wintersteiner have just announced the isolation of crystalline progestin with the empirical formula of $C_{21}H_{30}O_2$.

activity per mg gave only a faint Sullivan reaction, although 3.10 per cent. sulfur was present. In the case of both series of preparations increasing potency was attended by an increase in sulfur content. Another finding which may be of significance was the high tyrosine or rather phenolic value of both series of fractions, which markedly increased upon concentration of the active principles. Of the two samples mentioned above the pitocin contained 14.3 per cent. tyrosine, while the pitressin sample contained 10.5 per cent. Further work is being carried out along these lines and in further attempts to purify the active principles.

The sulfur of these preparations attracted our attention, and we felt it would be interesting to study the reduction of the pitressin and pitocin with cysteine. Under conditions which we have shown that insulin is completely inactivated by cysteine, we have found, with Mr. Sealock, that pitressin and pitocin retain their activity. Secondly, benzylation of the reduced pitressin and pitocin causes disappearance of their physiological activity. The treatment of the unchanged pitressin and pitocin with benzyl chloride resulted in no loss of activity. This clearly shows that we had obtained actual reduction of the disulfide to the sulfhydryl form of pitressin and pitocin by the action of cysteine and secondly that the reduced forms of these hormones are active. Probably what is most significant, however, in these experiments is the fact that they present almost conclusive proof that the hormones themselves actually contain sulfur, although it had already been known from the earlier work of Sullivan and Smith that loosely bound sulfur was present in extracts prepared in the usual fashion from the Standard Powdered Pituitary and that it tended to parallel the activity.

There is one other point I would like to make before closing this discussion. The isolation of adrenaline and thyroxine and their turning out to be relatively simple low molecular weight compounds has led us to expect that all hormones would likewise be of the same order of complexity. Furthermore, the fact that thyroxine seems to be linked with a protein as thyroglobulin in the thyroid gland has by analogy tended to lead us to expect that, where a hormone is isolated in crystalline form and exhibits protein behavior, there must be linked to the protein a prosthetic grouping. In other words, in the case of the hormone of the thyroid gland, it could be regarded that it was the prosthetic grouping that was isolated in crystalline form, whereas in other instances it might be the protein plus prosthetic grouping that happened to be isolated. We may have to keep our minds open to the possibility that a protein might in itself have physiological behavior not necessarily attributable to a prosthetic grouping as such. With the growing insight into the fact that enzymes may be proteins and with the realization of the rôle of proteins as toxins, antitoxins, antigens, antibodies and the like, this idea may seem more and more possible.

RAINMAKERS ON THE PLAINS

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UP to the Civil War the Great Plains of this continent stood condemned as the Great American Desert. Buccaneer Coronado, the first white man to penetrate the domain of the buffalo in the sixteenth century, was also the first to christen it a desert. Three centuries later the fiction of the plains desert was confirmed by such prominent expeditionists as Zebulon M. Pike, John Bradbury, Major S. H. Long and others. That the pronunciamentos of these men were taken seriously is indicated by the fact that all good geographical textbooks described the Great American Desert to and even after the fifties. Yet, at this time and immediately following it, history records the greatest settlement of these drier lands.

That early settlers entered this once so-called desert area so precipitously was not merely the result of a leap-frog method of advance. Although mechanical devices facilitated the pioneer's advance after the middle of the nineteenth century, more significant was the fact that a desert concept was simultaneously exploded by what was then considered a newly discovered meteorological doctrine. It was alleged that the presence and activity of the white man was altering a set of meteorological phenomena which made for aridity and that the belt of greater rainfall was migrating westward.

The early plainsman's psychosis made it relatively simple to promulgate what in retrospect seems a rather ludicrous idea. He was as replete with self-reliance and faith in the Almighty as he was devoid of worldly means and accurate knowledge of the plains. Lack of information and a naïve disposition towards the powers that be, other than political, rendered him very impressionistic. The vigorous life of the frontier made it highly soothing to his ego to hear that he was wrestling with the moulding forces of the universe. That his presence and activity on the plains should effect a change in a cosmic law pleased him more than a little. Agents to proclaim the new order were not lacking. They were mainly real estate men, railroad-promoters and ministers.

It is to be remembered that every pioneer had heard much about the Great American Desert. That such a desert never existed he did not suspect. Yet here he found himself on the plains, producing crops with varying success. The conclusion was inescapable that annual precipitation had increased. The varying amounts of rainfall further encouraged the false conception concerning increased rainfall. The late seventies and early eighties were relatively moist years. In contrast to them stand the years of the late eighties and early nineties. The misconception naturally received its greatest fillip during the former period.

One of the earliest expressions of the theory of the westward migration of rainfall is to be found in Gregg's "Commerce of the Prairies," which appeared in the forties. He writes of the matter as follows:

> The high plains seem too dry and lifeless to produce timber; yet might not the vicissitudes of nature operate a change likewise upon the season? Why may we not suppose that the genial influences of civilization—that extensive cultivation of the earth—might contribute to the multiplication of showers, as it certainly does of fountains? Or that the shady groves,

as they advance upon the prairies, may have some effect upon the season? At least, many old settlers maintain that the droughts are becoming less oppressive in the West. The people of New Mexico also assure us that the rains have much increased of latter years, a phenomenon which the vulgar superstitiously attribute to the arrival of the Missouri traders. Then may we not hope that these sterile regions might yet be thus revived and fertilized, and their surface covered one day by flourishing settlements to the Rocky Mountains?

The Mormons of Utah were next to encourage the belief that rainfall was increasing in the West. The erroneous speculation of these people on this matter had its inception in the observation that the level of Salt Lake was gradually rising. In popular discussion it was soon suggested that the cultivation of the desert lands by the system of artificial irrigation had brought about the climatic change. Prominent members of the United States Geological Survey were prompt to deny such an absurd hypothesis. Local wiseacres to perpetuate and spread the misconceptions, however, were not lacking.

By the end of the Civil War the miasma of the misconception of increased rainfall was already at large on the plains. In 1866 the Commissioner of Public Lands recommended a measure to Congress which would compel the plains pioneers to forest a high percentage of their land with the view of increasing rainfall in the region. A few years later Congress heeded this suggestion by the Act of 1873, which purported to encourage the growth of timber on the prairies. The Act of Congress gave statutory dignity to a conception which was shortly to make the plains the mecca of homeseekers from regions as remote as central Europe.

The seventies and early eighties constituted the boom period of the plains. Overnight there sprang up a motley array of local boosters who described and advertised the West as never before. The westward migration of rainfall constituted the dominant note of these voices in the wilderness. The Reverend Mr. C. S. Harrison, of York, Nebraska, in a prize essay on the topic in 1873 expressed the advanced belief on this matter at that date. He says, in part, as follows:

The curse of God falls heavily on the people who ignore His grand design and rob the lands of forests. Egypt was once one of the most fertile and wealthy countries. Remains of petrified forests yet attest what her defences were against the drifting sands. These were destroyed and Egypt became a desert. Palestine was a land flowing with milk and honey. . . .

This world was made for man's comfort, and it is placed in his keeping; if he abuses it, retribution is sure to follow. . . .

Portions of Utah, considered rainless, have been watered by showers since trees have been planted. There is some foundation for the belief that rain follows the white man. Providence seems to encourage the adventure of men as they push westward. The mythical desert will doubtless be covered with beautiful groves and fruitful orchards even to the base of the Rocky Mountains. In many places where streams and springs have been dried up by the removal of the trees, they have been recalled by the planting of their protectors.

The wide, open tracts of land on the plains which seemed to invite cultivation stirred the imagination of many Easterners as well as of thousands of home-seeking Europeans. Information concerning the new country in the West was read with avidity. Railroad and community brochures were printed and circulated gratuitously. Other printed material, which purported to be of a more unbiased nature, also found a ready and wide-spread market and consequently appeared in ever-increasing numbers. Of such a nature was a booklet, "Nebraska As It Is" (1878), by L. D. Burch, then editor of the Chicago *Commercial Advertiser*. The author's flattering descriptions of this state have been excelled by only a few writers. With reference to the rainfall in the state, the author says:

From the increasing rainfall of the state, it is also evident that at no distant day the whole state as far as to its western limits, will have an abundant rainfall for all the needs of the agriculturalists.

In another chapter he says:

If the drouth and Hot Winds of the early years were serious drawbacks to early settlement, they certainly are not in these later years, for they have passed away with the causes that produced them. There is far more apprehension of excessive moisture among the farmers of the state today than there is of excessive and prolonged drouth or heat, and yet danger from this direction is almost entirely obviated by the admirable natural drainage of the country.

Nebraskans cherished this hope and conviction concerning the westward migration of rainfall. Conflicting reports were greatly resented. This is well illustrated in the instance of a report published by the Department of the Interior in 1879, entitled "Lands of the Arid Region." This report is based on information gathered by Major J. W. Powell when in charge of a United States geological survey in the West. He had spent years on the plains and could speak authoritatively on the subject by virtue of having traversed the region many times and also because of his scientific training. Time has largely vindicated his observations. His report in part runs as follows:

The limit of successful agriculture without irrigation has been set at 20 inches, . . . at 20 inches agriculture will not be uniformly successful from season to season. Many drouths will occur . . . and it may be doubted whether, on the whole, agriculture will prove remunerative. On this point it is impossible to speak with certainty.

In his opinion the 100th meridian in this country constituted the line of demarcation between irrigable land and non-irrigable lands.

Nebraskans challenged the report. Robert W. Furnas and Martin Dunham, both prominent educators and political leaders in the state, sent a letter of inquiry to Professor Samuel Aughey and to C. D. Wilber at Lincoln, asking what facts there were to sustain such a report. Their reply illustrates that academic circles also shared in the belief of increasing rainfall in the West.

Observation, experiment, and the highest scientific authority demonstrate that climates in the west are becoming moister; that rainfall is increasing steadily. This increase must extend until the plains east of Denver and Laramie receive sufficient rainfall to produce farm products without irrigation. . . . For these reasons we are compelled to say that any evidence of present dryness, where dryness exists, is evidence only for the present, and should not be used to cover these areas with the undeserved reproach of the curse of desert lands.

The question arises, What facts or data could be supplied to defend this position? In the report of the Nebraska State Horticultural Society, 1878–79, Mr. Wilber obliges us with his theories concerning this phenomenon:

In a word, it is caused by the plow . . . it converts a desert into a farm or garden. . . . A desert however is the result of conditions that can be controlled by the genius and industry of man. . . . The moisture contained in the atmosphere over this new made surface of living green will not dissipate and pass away with the winds, as formerly, but will condense, by the well-known law, both as dew at night and into clouds, under the influence of electric currents. With the clouds comes precipitation, which will be greatly increased as the condensing surface increases by the constant efforts of the farmer to enlarge his domain of crops. . . .

With a logic that cannot rest we are forced to this conclusion, that the agencies of civilization now in action are such as will secure a complete victory over the wilderness and waste places of western territory. The plow will go forward; "God speed the plow."

In 1880 appeared Samuel Aughey's "The Physical Geography and Geology of Nebraska." The book, in this instance, is as interesting and significant as its author. It is the first scientific treatise on the geology, geography,

climatology, flora and fauna of this state. The material it contains is nearly all based on first-hand information which the author had gathered in his many trips over the state. The book not only treats of a frontier region, but in and of itself it is also decidedly frontier in character. As such, it should move us to be generous towards the author and some of his visionary and strange conceptions.

Professor Samuel Aughey, Ph.D., LL.D., was the head of the natural science department in the University of Nebraska from 1871 to 1883. That he was a man of national reputation is indicated by the fact that he was a prominent member of the St. Louis Academy of Science, the Buffalo Academy of Science, the American Association for the Advancement of Science, the Iowa Academy of Science and other similar societies. Trained to be a theologian, he spent several years in the pulpit. It was in such a capacity that he came to Dakota City, Nebraska, in 1864. His interests, however, also encompassed things scientific, and he spent much time and effort studying geology, chemistry and botany. Upon his arrival in Nebraska he found an almost untouched field of study along these lines. In a few short years, through his field researches, he became one of the most respected, admired and popular scientific figures on the Nebraska plains. His theological training served him in good stead among the country folk of the state. Dr. A. E. Sheldon, secretary of the Nebraska State Historical Society, who knew Professor Aughey, says that next to God, Professor Aughey was the best known, liked and respected figure in Nebraska. Professor Aughey was the most outstanding champion of the rainfall-migration theory. His support of the theory gave it the stamp of scientific approval. Critics of the theory could hardly gainsay the words of a man who was at once a Ph.D. and an LL.D.

Professor Aughey's advocacy of the migration of rainfall was not the result of armchair speculation. No man had made closer observation and studies of the geography of the plains; few were better versed in scientific literature. He noted that precipitation data for the late seventies actually did show a slight tendency for increased rainfall. Lack of data covering a large period of time naturally made such slight increases a subject of fertile speculation. Other observations indicated the same tendency. Professor Aughey observed in his peregrinations over the state that many new springs had begun to flow. He also noted the "appearance of water in old creek beds, where it apparently had not been flowing for ages." He speaks of an alleged change in vegetation as follows:

> The changing vegetation of the State proves the same fact. There was a time within the memory of many now living when buffalo grass was the most conspicuous vegetable form west of the Missouri. . . . Now how changed. It has almost entirely disappeared for two hundred miles west of the Missouri. There is comparatively little of it now on the third hundred. Every year it is retreating further westward. Its place is supplied with grasses indigenous to moisture climates.

It must be admitted that the above observations can not be denied *in toto*. Possibly new springs did occur, and streams again did continue to flow in dry stream beds. That the type of grass did change seems doubtful, since no transformation in grasses has been noted in the unbroken fields.

Professor Aughey did not subscribe to every fabulous theory that proposed to explain the alleged increasing rainfall. He discounted secular reasons which were cited because he found no spontaneous causes to effect them so promptly and profoundly. He also discredited and criticized the popular belief that the railroad lines and telegraph lines were responsible for the alleged greater rain-

fall. Strangely enough, a wide-spread popular conception held that every yard of steel rail laid in the desert would draw from the heavens a gallon of water per annum.

Professor Aughey held that the planting of trees on the plains might be a helping cause to more rains, yet that such vegetation could not alone account for the greater amount of moisture experienced. He said:

It is the great increase in the absorptive power of the soil, wrought by cultivation, that has caused, and continues to cause an increasing rainfall in the state.

Any one who examines a piece of raw prairie closely, must observe how compact it is. Every one who opens up a new farm soon finds that it requires an extra force to break it. There is nothing extraordinary about this. For vast ages the prairies have been pelted by the elements and trodden by millions of buffalo and other wild animals, until the naturally rich soil became as compact as a floor. When rain falls on a primitive soil of this character, the greater part runs off into the canyons, creeks and rivers, and is soon through the Missouri on its way to the Gulf. Observe now the change which cultivation makes. After the soil is broken, a rain as it falls is absorbed by the soil like a huge sponge. The soil gives this absorbed moisture slowly back to the atmosphere by evaporation. Thus year by year as cultivation of the soil is extended, more of the rain that falls is absorbed and retained to be given off by evaporation, or to produce springs. This, of course, must give increasing moisture and rainfall.

To show that this theory had elements of truth in it, Professor Aughey cited an experiment he had made on several occasions. Blocks of "sod soil" and of cultivated soil, of equal size and in close juxtaposition, were weighed before and after rains, and in each instance it was found that the latter absorbed a much greater amount of moisture. The experiment was varied somewhat and carried on many times to eliminate chances of error. The cultivated soil, the professor noted, absorbed as high as ten to twelve times the amount of moisture the sod soil did. To be conservative in the matter, he sets the general ratio in this matter as eight to one.

Professor Aughey's opinion concerning the alleged westward migration of rainfall appeared in many publications and was received with enthusiasm both in America and Europe. The revolutionary nature of this theory made it a topic of conversation. Whatever inertia it still possessed was completely and effectually overcome by the impact of railroad advertising. Several hundred thousand copies of descriptive pamphlets prepared by Aughey were promptly circulated by the railroads. The unparalleled influx of settlers into Nebraska in the late seventies and early eighties stands in part as a permanent tribute to the achievements and opinions of Samuel Aughey.

C. D. Wilber, LL.D., was Professor Aughey's satellite as a frontier publicist. Being a man of many interests and not being particularly adept in any field of study, he possessed the happy faculty of rationalizing as his inclination dictated. Mr. Wilber, like many of his contemporaries in Nebraska, owned some real estate which it was hoped would rise in value. It is not altogether peculiar that he and the other proprietors greatly deplored the unfortunate attitude and conception Easterners held concerning the plains region—particularly that portion in and about Nebraska. To dispel the false conception of Easterners, Mr. Wilber wrote "Nebraska and the Northwest" (1881).

Mr. Wilber received his inspiration for his work as well as much of the actual material from Professor Aughey's "The Physical Geography and Geology of Nebraska." The latter work, although it frequently soars into the realm of fancy, reflects the spirit of the scientific method. Wilber's work is of a more popular nature and shows clearly what the author liked to believe was true of Nebraska. His descriptions and opin-

ions are so positively naïve, as well as misleading, that we shall quote somewhat liberally from his chapter on rainfall. Following are some of Mr. Wilber's opinions as they bear on this subject:

> By the repeated processes of sowing and planting with diligence the desert line is driven back, not only in Africa and Arabia, but in all regions where man has been aggressive, so that in reality there is no desert anywhere except by man's permission or neglect. . . .
>
> Palestine is now comparatively a desolation, for the simple reason that the gardener's occupation is gone. It once sustained, as we are credibly informed, a vast population. Nor is there any doubt that both these noted valleys can be brought back to their former productive ability by applying the same means that have been so long neglected. . . .
>
> It requires only the condensing surface of growing verdure; it may be of trees or shrubs or growing grain, over large areas; or, in short, just such a changed surface as man necessarily brings about as a tiller of the soil, to compel the moisture to make clouds form in the atmosphere, instead of being dispersed by the daily radiation of solar heat. . . .
>
> . . . the Indians are, and, as far as we know, have always been, co-workers with the natural forces that maintain and extend desert conditions. . . .
>
> To those who possess the divine faculty of hope—the optimists of our times—it will always be a source of pleasure to understand that the Creator never imposed a perpetual desert upon the earth, but, on the contrary, has so endowed it that man, by the plow, can transform it, in any country, into farm areas.

The work of Samuel Aughey and of C. D. Wilber made the theory of the westward migration of rainfall acceptable in the best of scientific circles. Institutions that wished to advertise the West could now point to the best of authorities for their optimistic claims concerning the plains. Those who were contemplating a new home and a new start in life on the plains responded unhesitatingly to the sirens of the plains.

Orange Judd, editor of the *Prairie Farmer* at Chicago, was one of the most widely known agricultural writers in the United States at the close of the nineteenth century. Mr. Judd was a staunch believer in the alleged westward-migration-of-rainfall theory. His opinions on the matter, as reflected in his magazine, were read most widely by the rural people, who were most likely to respond to the alleged attractions of the plains lands.

Mr. Judd was also an eloquent speaker and so was invited to deliver an address at the Nebraska State Fair at Lincoln, in 1885. He accepted and delivered an address on the causes and importance of increasing rainfall in Nebraska. His statements are not characterized by brilliant reasoning on the subject; however, such reasoning was hardly required by the temper of the times. The gist of Mr. Judd's address was that there is always enough moisture in the sky above to furnish a rain if only some way could be devised to bring it down from overhead. He says in part as follows:

> There is just as much water in the bright, clear sky above you at this hour as there is on the most densely cloudy day, or as there is during the severest rain storm. Electrical conditions, or currents of colder air, or other influences lower the temperature, the hidden moisture comes out and falls, as I have described.

Of course, Mr. Judd's major premise concerning the amount of moisture in the air is fallacious. Also, his description of how the moisture is to be condensed is vague and misleading. However, the audience and the speaker found it convenient and satisfying to believe what the substance of the speech indicates. The audience was assured, in conclusion, that

> As neighboring Kansas settles up and breaks the prairie sod away out to its western border those parching winds that formerly came up into Nebraska and still come at some points, will be heard of no more.

All the railroads on the plains, with the exception of the Union Pacific, were built with the conviction that the land possessed agricultural possibilities. Expected through or terminal business hardly warranted such a gigantic and expensive undertaking. All these roads, therefore, set themselves to the task of settling the West. The advent of such encouraging prophets as Aughey, Wilber and Judd was most satisfying and gratifying. Pamphlets and brochures were soon prepared that embodied the alleged fact of westward migration of rainfall. These were circulated with abandon both in the United States and in portions of Europe from which settlers might be attracted.

The fiction of increased rainfall on the plains proved so popular and profitable as to evaporate all interrogations as to its validity. Only a cruel "weather man" could and did blast this effectively entrenched conviction. In the late eighties and early nineties occurred a series of dry years. Crop failure followed crop failure. Want and distress became wide-spread over the plains. A beautiful theory of increasing rainfall became but a haunting and mocking memory to thousands who saw their substance wasting and parching about them. Better than eighteen thousand prairie schooners passed east over the Missouri River bridge at Omaha in one season—never to return. Frequently towns which in the eighties had a population of several thousand had completely disappeared by the middle of the nineties. Caravan after caravan which had served to bring the pioneer family west was re-outfitted to carry it away from this land of deception. On many a prairie schooner the owners expressed their bitter hearts as follows:

> In God we trusted,
> In Kansas we busted.

ANIMAL CARTS

HOW MARMOTS, BADGERS AND BEAVERS SERVE AS SLEDS OR WAGONS

By Dr. E. W. GUDGER

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When I was one of the graduate student body in zoology under Professor W. K. Brooks at the Johns Hopkins University years ago, among the other veils of ignorance which he attempted to lift from before our eyes was that behind which were hidden the works of the fathers of natural history. On those days he introduced at least one student to a field of study in which he has found very great pleasure

I well remember the day when he brought out and opened before us the five great folio tomes of the "Historiae Animalium" of Conrad Gesner, published at Zurich 1551–1587. Little did I think then that years later I was to become well acquainted with that volume entitled "Historiae Animalium, Liber IIII, Qui Est de Piscium & Aquatilium Animantium Natura . . ." Tiguri (Zurich), 1554.

Of that talk by Professor Brooks I have a very strong recollection in a very poor memory of his telling us that Gesner stated that rats transported eggs in this interesting fashion. A rat lies on his back, others roll an egg up onto his belly where he holds it with all four paws, while the others grasping his tail drag him along—an animated sled—to their burrow. And as Professor Brooks spoke I could visualize the scene, and I have done so for 30 years—mistakenly.

About a year ago I prepared an article (now in press to appear in *Isis*) on the five early naturalists and their foundational work in ichthyology—Gesner standing fourth in the series. While engaged on this study (with this old story in the back of my head) I went to Professor Brooks's article on Gesner in the *Popular Science Monthly* (1895, Vol. 47) where on p. 57 I found the story told, not about the rat, but about a different animal, another rodent, the so-called Alpine mouse or marmot. But to exculpate myself, let it be said that this beastie and the other rodents are put by Gesner in the section "De Muribus diuersis" of Liber I of his old folio —our copy of which has wooden covers and brass clasps.

And now being bone-tired with working for sixteen months on the problem of abnormalities in flounders, I am going to ease up the strain by going off at a tangent—ending in this subject named, about as far from fishes as can well be.

The "Alpine Mouse" or Marmot as a Hay Sled

Here is what Professor Brooks did say on this subject, as published in his article:

> They [the Marmots] make use of a peculiar device for bringing home their hay. If they have gathered a great quantity they need a wagon to carry it, and one of them lies down on his back, and, lifting his feet toward heaven, forms supports ["standards"] like those of a hay wagon between which the others pile the hay. When the cart is loaded, the other marmots take the tail in their mouths, drag their brother home like a sled, and, after unloading him, put the hay in their holes. As each one takes his turn of service as a sled, none of them have any hair on their backs at this season of the year.

This is translated from page 842 of Volume I of Gesner's "Historiae—De Quadrupedibus Uiuiparis" (Tiguri, 1551). Gesner gives a figure of the

Alpine mouse, but unfortunately not of the scene depicted.

This story is also related by Edward Topsel, whose "History of Four-footed Beasts" was published at London in 1607. This not being available, I quote from the second edition (London, 1658, p. 407). Topsel tells us that his book was largely "Collected out of the Writings of Conradus Gesner." However, he introduces an interesting variation from Gesner's account, which shows that he had either had experience or observation of hay-hauling. Since the hay was liable to slip off this animated hay sled, some precaution had to be taken. Here is Topsel's account, including the addition:

> Towards the feast of Saint Michael the Archangel, and of Gallus, they enter into their Caves; and as Pliny saith, they first of all carry provision of Hay, and green Herbs into their Den to rest upon, wherein their wit and understanding is to be admired; for like Beavers one of them falleth on the back, and the residue load his belly with the carriage, and when they have laid upon him sufficient, he girteth it fast by taking his tail in his mouth, and so the residue draw him to the Cave; but I cannot affirm certainly, whether this be a truth or a falsehood. For there is no reason that leadeth the Author thereunto, but that some of them have been found bald on the back.

It is difficult to keep a load of hay from slipping off a hay wagon or sled, so a "spring pole" is used. The larger end is permanently lashed to the front of the hay frame and, after the hay is loaded, the flexible pole is bent or sprung down lengthwise of the frame and lashed behind. In Topsel's account the rat's tail serves this same purpose.

However, Gesner was not the originator of this story but had it from Pliny the Elder (23 B. C.–79 A. D.), as he expressly notes. In Pliny's "Natural History," in the well-known translation of Bostock and Riley (London, 1890, Vol. II, Book viii, Chap. 55, p. 308), is found another interesting variant as follows:

> Some writers say that the male and the female [marmots], lying on their backs alternately, hold in their paws a bundle of gnawed herbs, and the tail of each being in turn seized by the teeth of the other, in this way they are dragged to their hole.

This is surely a fine illustration of cooperation in burden-sharing and it explains why all the members of a colony (males and females alike) are alleged to be found hairless in the dorsal region. However, John Timbs in "Strange Stories of the Animal World" (London, 1866, p. 372) alleges that "they use an old [and presumably otherwise useless] she marmot as a cart; she lies on her back, the hay is heaped on her belly and two others drag her home."

The Sieur de Beauplan lived seventeen years in the Ukraine (when I do not know) as "ingineer" to the King of Poland. He wrote "A Description of Ukraine," which was Englished in Churchill's "Collection of Voyages" (Vol. I, London, 1704). I quote him from the second edition (Vol. I, Pt. II, p. 542), London, 1732. He writes of a rodent which he calls bobaque or babaque, which seems to be our marmot or a very close relative. Of these beasties he writes thus not merely to adorn a tale but to point a moral concerning laziness:

> They are great sleepers and good managers, nature directing them to lay up provision, insomuch that one would think there were slaves among them, for they take those that are lazy and lay them on their backs, then lay a great handful of dry herbage upon their bellies, which they hold fast with their paws, or rather hands, because they make use of them almost as monkeys do: then the others drag those drones to the mouths of their burrows, and those creatures serve instead of barrows, whence they make them carry the provision into their holes. I have often seen them practice this.

The Badger as a Wheelbarrow

The badger is digger of burrows in the ground and as such needs to get rid of the "spoils" from his deep "earths."

To the average person this would seem to be a matter of some difficulty, but not to our old naturalist. Gesner on page 780 of his Volume I describes how it is done and Topsel translates him as follows:

> When they dig their den, after they have entred a good depth, for avoiding the earth out, one of them falleth on the back, and the other layeth all the earth on his belly, and so taking his hinder feet in his mouth, draweth the belly-laden Badger out of the cave, which disburdeneth her cariage, and goeth in for more until all be finished and emptied.

Here is found a change in the method of haulage. The badger's tail is short, so the motive power lays hold of the hind feet. Notice here Topsel's delightful indifference to the sex of the badger wagonette and his quaint spellings—I love his "avoiding."

This account of Topsel's has been often copied. For instance, it is found practically unchanged in the "Gentleman's Recreation" (1677) by Nicholas Cox.

The Beaver as a Wood Wagon

The allegation that an individual beaver may be used to transport bits of wood, just as the marmot is used for the transport of hay, we also owe to the "German Pliny," Conrad Gesner. It is found on page 338 of the volume quoted. Next there are three lines given to it in the first edition of Olaus Magnus's "Historia de Gentibus Septentrionalibus" (Romae, 1555, p. 604). This author's book is illustrated by so many quaint and interesting old woodcuts that I had hoped for one here, but the artist missed his chance.

It has not seemed worth while to translate either Gesner's or Magnus's statements; this has been done by old Topsel (1658) with suitable embellishments. Let us hear him. After describing how the tree is felled, due regard being taken "to discern when it is ready to fall, lest it might light upon their own pates," he then goes on:

> The tree being down and prepared, they take one of the oldest of their company, whose teeth could not be used for the cutting (or as others say, they constrain some strange Beaver whom they meet withal) to fall flat on his back (as before you have heard the Badgers do) and upon his belly lade they all their timber, which they so ingeniously work and fasten into the compasse of his legs that it may not fall, and so the residue by the tail draw him to the water side; . . . and this seemeth to be true, because there have been some such taken, that had no hair on their backs.

This seems pretty hard treatment of a stranger. And so Topsel thought, for he adds—"which [hairlessness] being espied by the hunters, in pity of their slavery, or bondage, they have let them go away free." Thus it is seen that there is more kindness in the hearts of the "cruel hunters" than in those of the "kindly beavers."

This account of Topsel's is from the 1658 edition of his book, on the title page of which his name has but one "l" instead of the two generally used. However, the first edition appeared in 1607. This I have not seen, but it surely contains the accounts quoted. But a scant half dozen years later (1613), Michael Drayton published his poem, "Poly-olbion." In this he described nearly everything in Great Britain, including the animals. Concerning the use of the beaver as a wood-wagon I quote from the "Sixt Song" (pp. 88–89) of Part I of his work, as reproduced in facsimile from the Spenser Society's reprint of the 1622 edition.

> A forraging he goes to Groues or bushes nie,
> And with his teeth cuts downe his Timber: which laid-by,
> He turnes him on his back, his belly laid abroad,
> When with what he hath got, the others do him load,
> Till lastlie by the weight, his burthen hee have found.
> Then with his mightie taile his carriage having bound
> As Carters doe with ropes, in his sharpe teeth hee grip't
> Some stronger stick: from which the lesser branches stript,

He takes it in the midst; at both the ends, the rest
Hard holding with their fangs, unto the labour prest,
Going backward, tow'rds their home the loaded carriage led,
From whom, those first heere borne, were taught the useful Sled.

Here are introduced two new and interesting helps in wood hauling. The wood is evidently loaded crosswise of the "wagon," since his tail is used to hold it on (recall how the marmot holds the hay from slipping), just how is not made clear. But clear is the method of attaching the motive power. The loaded beaver holds crosswise in his mouth a strong and clean stick of wood, the other beavers lay hold of each end of this and backing away slowly drag their burdened fellow. This draws the beaver with and not against the slant of the hair, as all the other previous narrations have had their animals do.

Bishop Erich Pontoppidan, of Bergen in Norway, published in Danish at Copenhagen, in 1752, an interesting work, the English version of which is "The Natural History of Norway" (London, 1755). He and his book are often condemned for relating such stories as that now quoted:

> To transport these building materials to the spot, he [the Beaver] uses a most surprising address, as I am assured by many who have been witness. It is this. A number are employed on this work together; and one will suffer himself to be used as a cart, which the others, like horses, take hold of, fastening on him by the neck, and dragging him along; for this purpose he first throws himself on his back, with his legs up, between which they lay their already fitted and prepared timber; and in that manner bring it to the spot where the building is to be erected, one load after the other; but this always costs the first a bare back, for it takes all the hair off.

Just how the motive power beavers "fasten on him by the neck" is not clear, but it is significant that the beaver who serves as a cart has the going made as easy for him as possible. Pontoppidan and Drayton, of all the authors quoted, are the only ones who have the animals dragged with the slant of the hair. The others have their animal carts pulled against the lie of the hair, thus greatly increasing the friction of the animal's back on the ground and hence the difficulties of transport.

These accounts from the old books may of course be set down as fables, each probably having its origin in its predecessor, the ultimate source being Pliny's story. Where *he* got his account, no one can say.

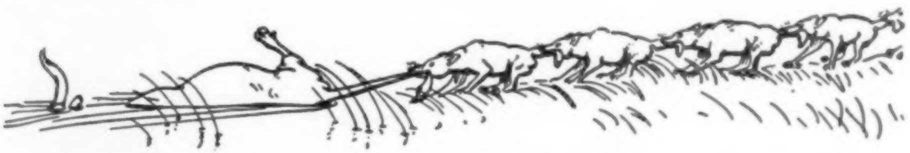
And now, having concluded the marmot, badger and beaver tail-dragging stories, may I drag in as a tail-section another interesting tale from old Topsel—that of wolves practising something of the same habit but on another animal. He writes thus on his page 573:

> But if they [the wolves] chance to see a Beast in the water, or in the marsh, encombred with mire, they come round about him, stopping up all the passages where he should come out, baying at him, and threatning him, so as the poor distressed Ox plungeth himself many times over head and ears, or at the least wise they so vex him in the mire, that they never suffer him to come out alive. At last when they perceive him to be dead and clean without life by suffocation; it is notable to observe their singular subtilty to draw him out of the mire, whereby they may eat him; for one of them goeth in, and taketh the Beast by the tail, who draweth him with all the power he can, for wit without strength may better kill a live Beast, then remove a dead one out of the mire: therefore he looketh behinde him and calleth for more help, then presently another of the Wolfs taketh that first Wolfs tail in his mouth, and a third Wolf the seconds, a fourth the thirds, a fifth the fourths, and so forward, encreasing their strength, until they have pulled the Beast out into the dry land: whereby you may see, how they torment and stretch their own bodies, biting their tails mutually, pinching and straining every joynt until they have compassed their desire.

The question, as to who or what was the source of Topsel's story, was solved by going to Gesner, where on page 724

of his "De Quadrupedibus" (Vol. I of the "Historiae," 1551) is found the account in Renaissance Latin.

To illustrate this account, which he quotes in his "Mammals of Illinois and Wisconsin," Mr. Charles B. Cory has had a figure drawn, and this I append as a fitting tailpiece to this tale in which tails form such a prominent feature in this account of animal tractors.



HOW THE WOLVES DRAG FROM A SWAMP A DEAD OX THAT THEY MAY DEVOUR HIM. FIGURE DRAWN TO ILLUSTRATE TOPSEL'S ACCOUNT. (AFTER CORY, 1912.)

MUNICIPAL HISTORY FROM ANATOMICAL RECORDS

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INTRODUCTION

THE tombs of the ancient dead with their human remains, accessories for future comfort and records vividly portray the culture of the times. It is almost startling to find that in a few institutions to-day unique catacombs of our contemporaries reflect in precisely similar manner the significant events of our own time.

Since 1911, all the cadavera received in the Anatomical Laboratory of Western Reserve University have been carefully documented by Professor T. Wingate Todd and their records and skeletal remains preserved in the Hamann Museum. Late in 1931, this collection included 2,139 individuals, of whom 82 per cent. were males and 18 per cent. females. Two thirds of the males and slightly more than half of the females were White; the remainder were American Negroes, with occasional Chinese, Mexicans and Indians. To determine the character of the population sample thus represented, the data from the death certificates and, in many cases, the clinical histories of these individuals were analyzed in the light of known historical and sociological facts. It was found that although this laboratory population constitutes but 1 per cent. of the total dead of the city of Cleveland for the twenty-one-year period during which it was assembled, it reflects to a remarkable degree the major concurrent social and industrial developments. This is because most of the cadavera were conscripted as unclaimed dead from the least stable elements of marginal economic groups in the living population, chiefly foreign-born Whites, their immediate descendants and American Negroes, people who with few exceptions were without skilled occupations.

SOCIO-ECONOMIC STATUS

Although there were twelve times more White than Negro deaths, only twice as many Whites arrived at the laboratory or relatively six times more of the Negro dead. Between 1911 and 1915 a large majority of the entering cadavera were White. Since 1915, there has been a practically uninterrupted in-

crease in the percentage of Negroes, until in 1930 and 1931 their number exceeded that of the Whites.[1] The Negro population of the city grew from 8,448 in 1910 to 34,451 in 1920 and 73,102 in 1930. The year 1915, when the Negro cadavera began to increase in relative number, marked the first major influx of Negro industrial workers from the South. The gradually rising percentage of Negro cadavera during the ensuing ten years may be accounted for simply by the population increase and low economic position of the Negro in the city. In the last five years, however, the proportion of Negro to White cadavera has been much greater than would be expected from the number of city deaths. Green's recent book[2] shows that in the recent depression the Negro has been by far the hardest hit of any Cleveland group.

Birthplace

The birthplaces of 1,177 or 55.6 per cent. of the cadavera are known. Of these 723 are White, 52.6 per cent. of all the White, and 453 are Negro, 61.1 per cent. of that group. There is internal evidence that the picture presented by the sample of known birthplace is true also for the entire lot, with a bias toward more foreign-born Whites. The table gives the origin by country of the foreign-born and by state of the native cadavera. Sixty per cent. of the Whites are of European birth, while only six individuals or 1 per cent. of the Negroes were born in foreign lands.

Foreign-born Whites: Twenty-five European countries are represented. The map in Fig. 1 shows more directly than the table the regional concentration of the birthplaces. The population

Fig. 1. Birthplaces of foreign-born whites in laboratory population, 1911–1931.

movements known as the "old" and "new" immigrations were both responsible for the presence in this country of these individuals whose common occupational level indicates a fairly homogeneous social stratum.

Native-born Whites: It was stated that the native Whites were principally of foreign parentage. This fact was officially recorded in only 49 instances. Fig. 2 reveals that, although the 292 known native Whites came from 21 states, the majority were born in three —Ohio, New York and Pennsylvania. When the Clevelanders, both White and Negro, who are largely children, are

Fig. 2. Birthplaces of native-born whites in laboratory population, 1911–1931.

[1] Cleveland Division of Health, "Statistical Reports, City of Cleveland, Ohio." Annual Municipal Reports, 1916–1929.

[2] H. W. Green, "Population Characteristics by Census Tracts, Cleveland, Ohio," Plain Dealer Publishing Co., Cleveland, 1930.

Origins of Subjects According to Race

	Foreign-born Whites			Native-born Whites			Native-born Negroes	
1.	Germany	83	1.	Ohio[e]	131	1.	Ohio[f]	76
2.	Austria	59	2.	United States	70	2.	Georgia	64
3.	Ireland	45	3.	New York	34	3.	United States	56
4.	Hungary	41	4.	Pennsylvania	21	4.	Alabama	51
5.	Czechoslovakia[a]	31	5.	West Virginia	5	5.	South Carolina	33
6.	Russia	30	6.	Illinois	5	6.	Tennessee	26
7.	Poland	28	7.	Michigan	5	7.	Virginia	24
8.	Great Britain[b]	22	8.	Wisconsin	4	8.	Kentucky	20
9.	Italy	20	9.	Tennessee	3	9.	Mississippi	18
10.	Canada[c]	12	10.	Massachusetts	2	10.	North Carolina	14
11.	Rumania	9	11.	Connecticut	1	11.	Arkansas	12
12.	Finland	8	12.	Rhode Island	1	12.	Maryland	6
13.	Greece	7	13.	Maryland	1	13.	Missouri	5
14.	Sweden	5	14.	North Carolina	1	14.	Indiana	5
15.	Jugoslavia[d]	5	15.	Texas	1	15.	Pennsylvania	5
16.	Switzerland	4	16.	Mississippi	1	16.	Florida	4
17.	Lithuania	4	17.	Kentucky	1	17.	Texas	4
18.	Bulgaria	4	18.	Missouri	1	18.	New York	4
19.	Mexico	4	19.	Indiana	1	19.	Kansas	3
20.	France	3	20.	Nebraska	1	20.	Michigan	3
21.	Denmark	2	21.	Arkansas	1	21.	Illinois	2
22.	Norway	1	22.	Washington	1	22.	Louisiana	2
23.	Holland	1		Total	292	23.	West Virginia	2
24.	Latvia	1		Foreign-born Negroes		24.	District of Columbia	2
25.	India	1	1.	Canada	3	25.	Massachusetts	2
26.	Europe	1	2.	West Indies	2	26.	Nebraska	2
	Total	431	3.	Abyssinia	1	27.	Minnesota	1
				Total	6	28.	New Jersey	1
							Total	447
							Additional	
						1.	China	1

Total White ... 723 | Total Negro ... 453 | Total Yellow-Brown ... 1 | Grand Total ... 1,177

[a] Czechoslovakia incl. 23 Bohemians
[b] Great Britain " 6 Scots, 2 Welsh, 1 Manx
[c] Canada " 1 Newfoundlander
[d] Jugoslavia incl. 2 Serbs, 1 Croat
[e] Ohio " 73 Clevelanders
[f] Ohio " 54 Clevelanders

subtracted from Ohio's total, this state still ranks first as a native birthplace. This fact must be attributed in part to the influence of the location of the laboratory. New York and Pennsylvania are precisely the states in which the people of the "new" immigration settled most thickly. Moreover, Carpenter[3] showed that beside the "new" groups, New York and Pennsylvania had in 1920 the highest percentages of Germans and English as well as many Irish who were particularly susceptible to urbanization.

[3] N. Carpenter, "Immigrants and their Children," Census Monograph, VII. U. S. Gov't. Printing Office, Washington, D. C., 1927.

Thus, among the foreign-born of the three states that have supplied most of the native Whites, there have been large contingents of both the "old" and "new" immigrations. The age distribution of the natives (Fig. 4) and the small series known to be of foreign parentage indicate that these native-born came more from the "old" stock than the "new." When the low economic status of these native Whites is considered, the regional concentration of their birthplaces is strong though indirect evidence of their foreign ancestry.

Negroes: An entirely different distribution appears for the birthplaces of the

FIG. 3. BIRTHPLACES OF NEGROES IN LABORATORY POPULATION, 1911–1931.

Negro cadavera (Fig. 3). These have come from 27 states and in representative numbers from a much wider territory than the White natives. A heavy majority, however, were born in Georgia, Alabama and South Carolina, the greatest centers of Negro population. Many came also from Tennessee, Virginia, Kentucky, Mississippi, North Carolina and Arkansas.

Most of these Negroes were part of the familiar northward industrial migration already mentioned. Kennedy[4] cites the increase in the Negro population of Ohio between 1910 and 1920 according to nativity from six southern states. As the industrial centers were the goals of the migrants, it is very probable that Cleveland received her share of these people in the same proportions. Certainly it is remarkable how nearly the same relative representation of these states occurs in the small laboratory series.

Still another movement is hinted by a few cadavera. As the "new" immigrant succeeded the "old" and the Negro followed the "new," so after the Negro has come the Mexican, who in the South has filled many jobs left vacant by the Negro. Though at present the Mexican has reached northern industry only in small numbers, four of his countrymen rest in our catacombs.

[4] L. V. Kennedy, "The Negro Peasant Turns Cityward," Columbia Univ. Press, N. Y., 1930.

AGE

The mortality curve of the cadaver population (Fig. 4) exhibits a peak in middle age. The median age of the collection is 45 years. Comparison of the curves of the component groups is illuminating. We note a distinctly old age curve for the "old" immigrants (median age 58 years), a middle age curve for the "new" immigrants (median age 42 years) and a still earlier one for the Negroes (median age 37 years). The native Whites have a less concentrated distribution (median age 45 years).

Immigrants as a class are composed of the active age groups, containing very few children and old people. Hence, our anatomical curves must be interpreted with consideration for three factors—economic level, characteristics of the immigration involved and the date of collection of the material. Hence the skeletal collection presents evidence of three mass movements and of the existing economic depression.

MIGRATIONS

Roughly about two hundred years ago a great colonization and national development program attracted settlers of the "old" immigration, who came from

FIG. 4. PERCENTAGE DISTRIBUTION OF STOCKS IN LABORATORY POPULATION BY AGE IN DECADES.

the British Isles, Germany and the Scandinavian countries. Since this immigration reached its peak in about 1880, thirty years before the collection was started, we should expect the cadavera of this stock to be the oldest, as they are.

With the beginning of a new era of accelerated industrial progress toward the close of the last century, hordes of "new" immigrants from eastern, central and southern Europe were called to this country to supply the unskilled divisions of labor. This movement was abruptly stopped by the war and later permanently restricted by law, thousands of the new-comers returning to their European homes. The "new" immigration reached its peak and sudden termination soon after our collection was begun, but as many of these people had come over in the two preceding decades, most of our "new" immigrants among the cadavera approximate middle age.

To fill the demands for crude labor created by the war and the reduced European supply, the Negro swarmed northward. The Negro migration occurred in the midst of the years of collection so that the truest picture of all would be anticipated in this group. Our records of duration of residence in Cleveland show that many of the first arriving of these Negroes are in our catacombs. The unusually early age peak of the Negro curve shows economic slaughter at its height.[5] Since there are few aged among the migrants and the survivors have not yet had time to grow old, there is no old age component in the Negro curve.

Causes of Death

Fig. 5, showing the highest seven causes of death in the cadavera, reveals that the diseases of poverty and exposure—tuberculosis, pneumonia and ex-

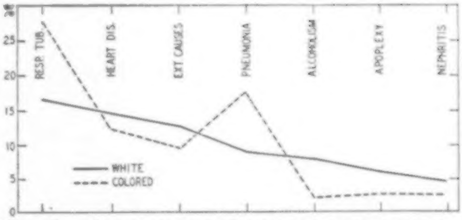

FIG. 5. SEVEN HIGHEST CAUSES OF DEATH IN CADAVERA, PERCENTAGES OF WHITE AND NEGRO.

ternal causes—have produced more casualties in this group than in the general population. Particularly is this true for the Negro cadavera among whom the respiratory diseases take the same precedence as in general Negro mortality.[6]

According to Rosenau, "The prevention of tuberculosis has become a sociological problem." The high incidence of tuberculosis among our cadavera of both races is evidence of the economic stratum in which these persons lived, confirming deductions from occupational data and from the fact that they were unclaimed.

There is a close similarity between this cadaver population and Pearl's population of persons necropsied at Johns Hopkins,[7,8] in respect to the age distribution by race and sex in their general populations. This similarity naturally follows the common social origin of the material.

Forecast of the Future

The population of Cleveland may now be said to be of an established and fairly stable character and, unless unforeseen social movements of great magnitude occur, the cadavera of the future will be

5 T. W. Todd, "Skeletal Records of Mortality," SCIENTIFIC MONTHLY, 24: 481–496, 1927.

6 M. Gover and E. Sydenstricker, "Mortality among Negroes in the United States," *Public Health Bulletin*, No. 174, 1928.

7 R. Pearl and A. Bacon, "Statistical Characteristics of a Population Composed of Necropsied Persons," *Arch. Path. and Lab. Med.*, 1: 329–347, 1926.

8 R. Pearl, "The Racial Origin of Almshouse Paupers in the United States," *Science*, 60: 394–397, 1924.

conscripted in the main from the elements that are in and about Cleveland to-day. Green's volume[9] affords an authentic source of information on the economic status of these several groups. His data suggest that the laboratory may expect to receive in the next ten years or so a minority of White cadavera of about 40 per cent. or less. The foreign-born should continue to constitute a large proportion of these but should be more of "new" than "old" immigrant stock for the unabsorbed remnants of the latter are fast disappearing. With the passage of time even the "new" foreign-born will come in progressively older age groups, just as our "old" immigrants have done, and then diminish in number as our "old" immigrants are now doing. The replacements in the younger age groups will be largely from natives of foreign or mixed parentage. The bulk of the Negro majority will probably continue to be of southern nativity and will tend to present a more normal age distribution. More females and young people may be expected. It is unlikely that the list of principal causes of death will undergo significant change.

[9] *Loc. cit.*

Summary

The characteristics of the cadaver population, comprising 2,139 persons in the Laboratory of Anatomy of Western Reserve University, namely, its conscription from the unclaimed dead of the city, its age at death, occupational level, mortality record, and racial composition, demonstrate that as a whole it is from a low economic stratum of society subjected to more than the usual hazards of modern life.

Though this cadaver population constitutes but 1 per cent. of the total dead of the city for the years during which it has been assembled, it reflects surprisingly closely the significant economic developments in the history of Cleveland during that period and it affords an enlightening insight into the social structure of modern American civilization.

Analysis of the factors determining the character of the present laboratory population permits certain general predictions concerning its future composition.

THE NORMAL CRIMINAL

By Dr. J. G. WILSON

CHIEF MEDICAL OFFICER, U. S. NORTHEASTERN PENITENTIARY, LEWISBURG, PENNSYLVANIA

THERE are many persons who believe that if a man is in prison, this, in itself, is evidence that he is an abnormal individual. On first thought, this seems to be a logical conclusion. Whenever a man gets into serious difficulty, especially if such difficulty shows unusually obnoxious behavior, his friends invariably come to his rescue with an excuse couched in such terms as these: "I have known this man a long time. I can not conceive how he can have done such a thing unless he is crazy"; or, "I've known him since he was a boy, and he could not have done this if he had been in his right mind." The fault in this opinion rests largely in the fact that we do not know what a normal or average man is. What do we mean by the term "normal"?

Broadly speaking, this word has three shades of meaning: the pathological, the normative and the statistical. If a man is sick he is not well, and therefore in the pathological sense he is abnormal. If a primary school does not come up to the standards of education set by the normal schools, it is abnormal in the normative sense. If a man is only four feet two inches high, he is abnormal in the statistical sense because he falls outside the normal deviations from the average so far as height is concerned. It is in this third or statistical sense that the term "normality" in relation to prisoners will be discussed.

First, let us consider the average man from the physical standpoint. Among 7,891 prisoners coming under observation in a large correctional and penal system during the year 1932, we found approximately 30 per cent. suffering from disease or physical defects, which if encountered in immigrants seeking admission to the United States would have resulted in their deportation as likely to become public charges on account of their inability to earn a living.

Although physical defects and disease are probably more prevalent and more serious among the criminal than the non-criminal group, we have no absolute proof that such is the case. In this connection we should remember that medical examinations of school children in all parts of the United States invariably reveal the presence of physical defects approximating from 20 to 50 per cent., depending largely upon the general standards of sanitation and medical supervision which prevail in the communities from which they are drawn. The large number of men rejected for physical defects in the drafts for the World War also indicates that the average individual in the United States is far from being physically perfect. If we consider perfection and normality as synonymous, it is quite evident that, from the physical standpoint, there are few normal men among the general population.

Even those who regard themselves as being in the "pink of condition" make frequent excursions into the realm of abnormality. Sometimes they have gas on the stomach and intestinal upsets with attacks of vomiting and diarrhoea. Probably 25 per cent. of the general population is constipated. After undue physical exertion, one is too tired to sleep and prolonged mental concentra-

tion also produces insomnia. The average man has had warts on his fingers, ingrowing toe-nails and corns and occasional attacks of sore throat, "athlete's foot" and poison ivy. As a baby, he had the prickly heat, and as an old man he has bleary eyes and the salt rheum.

It is certain, therefore, that if "normality" is considered equivalent to bodily perfection, the "average man" is not normal. But these minor physical defects with which average men are all more or less afflicted, do not prevent the average man from taking his proper place in society and keeping up his end of the load in a respectable and decent manner.

Many otherwise average men have physical defects of a distinctly pathological and chronic nature, such as exophthalmic goiter, pulmonary tuberculosis, rheumatic affections of the joints, lumbago and even gallstones and chronic appendicitis. Nevertheless, such afflictions are not regarded by them as excuses for anti-social acts, nor do they hinder them from expending all the energy at their command to make an honest living.

As there is no such thing as a perfect body, there is likewise no perfection of temperament or character. Inherently bad characters are due to faulty integration of temperament, will and intelligence.

The instinct of self-preservation frequently manifests itself in behavior which crosses the dividing line between legal and illegal acts. Pugnacity, which is one of the manifestations of self-preservation, keeps men out of trouble as well as getting them in. Acquisitiveness, another manifestation of the instinct of self-preservation, may make a man either a bank robber or a bank president. Young children naturally take whatever they want with no thought that they are doing wrong. Man is a natural born murderer, thief and robber and must be taught the difference between mine and thine.

The instinct of propagation of the species is so strong that it is only through a combination of circumstances that a larger number of normal men and women are not prosecuted for violation of the Mann Act.

The instinct for power, or the desire for domination and self-assertion, is at the root of all social progress. It is the force which spurs great men to action. During adolescence this desire to rule manifests itself in an overbearing attitude and resistance to advice from father, mother and teacher.

These natural traits occur in what many believe is an exaggerated form in all criminals. But, as a matter of fact, how do we know that such is the case? How many perfectly successful men who have never come in contact with the law were overbearing boys, played "hooky," stole watermelons and even on occasion lifted a quarter from their father's pocket? How many men, perfectly normal in the belief of their families and friends, have had sexual experiences which, had they been detected, would have landed them in jail? Shall we say that a man is abnormal simply because he has added the experience of being in jail to his long list of other anti-social acts?

Even the greater mental defects are by no means the exclusive possession of criminals. All epileptics are not in epileptic colonies or in prison. There are certainly more feebleminded outside of institutions than inside. Chronic alcoholism, supposed to be one of the chief causes of criminal acts, exists to a large extent among men who have never come in conflict with the law.

How many queer persons there are in every family! If the family is well-to-do and at the same time possesses a modicum of pride, the eccentric old-maid aunts, hobo uncles and ne'er-do-

well brothers do not often fall into the hands of the police and, when they do, by magic means they soon fall out again. There is no such thing as a perfect family. Every family has its black sheep, but all black sheep are not led to the slaughter.

Just as it is impossible to say with certainty what constitutes the normal criminal from the standpoint of his physical and mental health, so we experience the same difficulty when we seek to evaluate those factors which go to make normal heredity, environment and education.

There have been many studies which reveal the apparently large number of feebleminded ancestors of the feebleminded; but control investigations to show the absence of feebleminded or insane in the hereditary background of the individual with normal intelligence are not very convincing.

Although we may be unable to define exactly the term "abnormal family history," we know that the hereditary factor is of great importance in mental disorders. But it is obviously impossible to define "normal heredity." Every family has its black sheep, and all families have the genes of black sheep in their blood.

What is a normal social environment? For one man it will mean one thing, for another, another. In some parts of the country the presence of churches and the absence of Sunday baseball are considered necessary for community morals, and there seems to be a rather widespread belief that a child whose parents have been divorced has thereby been subjected to an overwhelming handicap. But, how many good and successful men have played Sunday baseball when they were boys, and how many broken homes are there where the children have made good in after life and how many failures where there was congenial parenthood! We know about the broken homes of criminals, but we do not know about the number of broken homes in families who have not contributed their quota to criminal institutions.

What is a normal family income? Twelve hundred dollars a year might be considered normal in some environments, and totally inadequate in others. Five thousand, ten thousand, fifteen thousand, twenty-five thousand, could all fall into the inadequate income class, depending upon the particular circumstances in the case.

What is a normal education? Moss and Hunt in their book, "Foundations of Abnormal Psychology," state that the latest statistics show that the average person does not even finish elementary school and that if a person's education is equivalent to the sixth grade child, he is just about average.

R. A. McGee, the educational director at the United States Northeastern Penitentiary, made a study of the previous education of the first eight hundred prisoners received at that institution. He found that their education ranged from illiteracy to postgraduate degrees. Nine per cent. were totally illiterate, 20 per cent. tested below the beginning of the fourth grade, 30 per cent. tested grades equivalent to the eighth grade or better, 20 per cent. above second year high school and approximately 15 per cent. had some college work. Although there is a wide range of educational attainments in this group, the medium educational grade status was the fourth month of the sixth grade, which coincides almost exactly with the figures mentioned by Moss and Hunt as the average for the general population.

In the statistical sense we conclude then that convicts are not recruited exclusively from the abnormal groups and that among them there are many who are just as normal as the average man in respect to economic status, education, mentality and health.

What kind of crimes do normal persons commit? The answer is; they may commit almost any kind of crime. Just as normal men are distributed throughout the legitimate occupations, so they are scattered through the illegitimate.

Broadly speaking, crimes can be divided into those where violence is or may be necessary for their consummation, and those where dishonesty without violence is the essential factor. The contention that the average or normal individual runs the gamut of all the subdivisions under these two general headings is supported by a study of 1,340 prisoners selected at random from the Federal Penitentiaries at Lewisburg, Pennsylvania, and Atlanta, Georgia (Atlanta 767, Lewisburg 573). The crimes of these prisoners ran all the way from rape to larceny, and included a fair sampling of every federal law violation serious enough to be called a penitentiary offense.

In this study we found that the crimes of exactly one half were committed by persons who, in the psychiatric classification, fell within the normal group. This included those committing both crimes of violence and crimes of dishonesty, but separating the two, we found that the normal group was more inclined to crimes of dishonesty than to crimes of violence, the proportion being 51.7 per cent. of the former to 37.5 per cent. of the latter.

Twenty-nine per cent. of crimes of violence were committed by persons with an intelligent quotient under 80 and 21 per cent. of such crimes were perpetrated by persons who fell into the general psychopathic group, under which are included not only the frankly insane, but also the psychopathic personalities and epileptics.

Thus it will be seen that although the normal criminal runs the whole gamut of the crime category, he is less prone to commit crimes of violence than the mentally abnormal; but aside from this, we find that when the occasion arises he will do practically anything that the feebleminded and the psychopathic will do.

His technique may differ, but he aims at the same goal. It would appear therefore that the question of normality or abnormality does not enter into guilt or innocence, responsibility or irresponsibility, but rather into the form of treatment which should be accorded individual violators of the law.

NATIONALITY OF NOBEL PRIZE WINNERS

By Professor HARRISON HALE

HEAD OF THE DEPARTMENT OF CHEMISTRY, UNIVERSITY OF ARKANSAS

AMONG those of the nineteenth century whose lives still influence widely our life to-day, few are more noteworthy than Alfred Bernhard Nobel. He was a chemist and an inventor, having taken out 355 patents in many different countries, but his interests were far-reaching. The practical applications of science and of business were in him combined with an unquenchable idealism.

Jokingly called "Europe's richest vagabond," Nobel was born in one country in Europe, left there at the age of nine, never to return except for periods of short duration, lived in at least five other European countries, besides a student residence in the United States. At his death the courts had to decide his legal residence; they chose Sweden, the country of his birth.

Born at Stockholm on October 21, 1833, he died on December 10, 1896, at San Remo, Italy. A year before in his will, signed at the Swedish Club in Paris, he made provision for the five prizes which now bear his name. In part this will reads:

> The prizes for physics and chemistry shall be allotted by the Swedish Academy of Sciences; those for achievements in the realm of physics or medicine by the Karolinska Institute in Stockholm; those for literature by the Stockholm Academy, and those for the promoters of peace by a committee of five persons to be selected by the Norwegian Storthing. It is my express wish that the prizes should be distributed without any regard to nationality, so that the prize may be awarded in all cases to the most deserving, whether he be a Scandinavian or not.

Many details had to be arranged in carrying out the provisions of this will, so that the first awards were not made until 1901. With some exceptions, awards have been made in each field every year. Explosives and petroleum were the basis of the fortune given the Nobel Foundation, estimated in 1901 at approximately eight million dollars. The amount of each prize varies year by year, from \$30,802 in 1923 to \$46,420 in 1931. More than four million dollars have been so distributed.

The financial view-point is not the most important. Writing in the SCIENTIFIC MONTHLY for January, 1931, Dr. Hans Zinsser, of the Harvard Medical School, says: "The establishment of the Nobel Prizes has had a far greater significance than the tangible rewards accruing to recipients. It has created international public recognition."

Assuming that the prizes have been awarded in accordance with the terms of the will "without any regard to nationality" so far as humanly possible, the study of the nationality of the winners for a third of a century furnishes at least to some extent a measure of the success of various nations in these fields. No one could claim this measure as infallible or even entirely accurate, but it is certainly suggestive as well as most interesting.

Occasionally a classification is difficult; thus Madame Curie, though born in Poland, is listed as French, because her work was done in France, and Einstein is classed as German, since he was a professor at Berlin in 1922 when the award was made. This study is not made in a spirit of narrow nationalism, rather of internationalism, as all true science, literature and peace are international.

Had awards been made in each field every year from 1901 through 1934, the

total would have been 170. The "List of Nobel Laureates," published in Stockholm in 1934 by the Nobel Foundation, records 141 awards from 1901 to 1933. Four additional awards have been made in 1934, giving a total of 144. In thirty of these, the award was a joint one, usually to two persons, in two cases to three; thus 177 persons have been so honored. The only person twice receiving an award was Madame Marie Curie, who shared the physics prize with her husband and with Henri Becquerel in 1903, and after her husband's death she alone was given the prize in chemistry in 1911. In Table I, joint awards to three are counted as one third, other joint awards made to two persons are counted as one half each.

TABLE I
NOBEL PRIZE WINNERS
1901–34

Country	Physics	Chemistry	Physiology Medicine	Literature	Peace	Awards 1901–18	Total
Germany	10	13	5	5	1	20	34
England	6	4½	3	3	2½	9	19
France	4	3	3½	4½	3½	11½	18½
United States	2½	3	4	1	5½	5	16
Sweden	2	2½	1	3	2	5½	10½
Switzerland	1	1	1	1	2½	4½	6½
Holland	3	1	1½	.....	½	4½	6
Denmark	1	.....	3	1	½	2½	5½
Austria	.....	1	2	.....	1½	2½	4½
Belgium	.....	.....	1	1	2½	3½	4½
Norway	.....	.....	.....	3	1½	1	4½
Italy	½	.....	½	3	½	2½	4½
India	1	.....	.....	1	.....	1	2
Poland	.....	.....	.....	2	.....	1	2
Russia	.....	.....	1	1	.....	1	2
Spain	.....	.....	½	1½	.....	1	2
Canada	.....	.....	1	.....	.....	.....	1
Ireland	.....	.....	.....	1	.....	.....	1
International	.....	.....	.....	.....	1	1	1
Total	31	29	28	32	25	77	145
Distribution	10	8	14	15	13	16	18

Eighteen nations are represented; three times the prize in peace has been awarded to organizations. One of these, the Institute of International Law at Ghent, receiving the prize in 1904, is classed as Belgian; the Permanent International Peace Bureau at Berne in 1910 is placed as Swiss; but the International Red Cross of Geneva in 1917 is best called international.

Only one woman has received an award in the sciences and she won two, Marie Curie of Paris being honored both in physics and in chemistry. No woman has won the prize in physiology and medicine. Three women have attained distinction in literature: Selma Lagerlöf of Sweden in 1909, Grazia Deledda of Italy in 1926, and Sigrid Undset of Norway in 1928. In peace, prizes have been given to Baroness Bertha von Suttner of Austria in 1905 and to Jane Addams of Chicago, who shared the award with Dr. Butler in 1931.

An examination of the table shows the largest number of awards have been made in literature and in physics, 32 prizes out of a possible 34 being the highest. In peace only 25 prizes have been given in 34 years.

Only six countries, one third of the eighteen to whose citizens awards have been made, received a prize in each field. The United States entered this group in 1930, when the prize in literature went to Sinclair Lewis. Prizes in chemistry have gone to only eight countries, in physics to ten, with a wider distribution in the other fields.

The preeminence of Germany is quite striking, especially in the physical sciences. The awards to France are more evenly distributed. The United States is outstanding only in the number of peace prizes received. On a basis of population, the standing of the leading nations relative to that of the United States would be improved, and Sweden, Switzerland, Holland, Denmark and possibly others would outrank us.

This position may not appeal to American pride, but it is well to face

the facts. Probably distance has been a handicap to Americans, but real efforts have been made to comply with the will of the founder, and the handicap should not be overemphasized. It may be a satisfaction to Americans to know that the position of the United States is improving.

A comparison of awards made before and since the close of the world war is shown in the last two columns in Table I. It appears that England and the United States have made a relative gain, that Germany, France, Switzerland and Holland have suffered a relative loss, while Sweden maintains about the same standing. Seventy-seven prizes were listed from 1901 to 1918, and sixty-eight have been given since. Only two new nations have been added, Ireland and Canada, and these have much in common with England.

It is evident that though Germany has lost relatively since the war, her supremacy is easily maintained in both periods. England and the United States seem to be gaining on France, and England seems likely to surpass her.

At any rate, to those who care for such things it is as interesting as a big league baseball record. The habit of adjusting one's self to the standings after the prizes are announced each November might be worth while.

American Nobel Prize winners are:

Physics:

1907—Albert A. Michelson, died 1931; professor of physics, University of Chicago.

1923—Robert A. Millikan, director of physics laboratory and chairman of executive council, California Institute of Technology, Pasadena.

1927—joint award, Arthur H. Compton, professor of physics, University of Chicago.

Chemistry:

1914—Theodore William Richards, died 1928; professor of physics and director, Gibbs Memorial Laboratory, Harvard University.

1932—Irving Langmuir, research laboratory, General Electric Company, Schenectady, N. Y.

1934—Harold C. Urey, professor of chemistry, Columbia University.

Physiology and Medicine:

1912—Alexis Carrel, Rockefeller Institute for Medical Research, New York City.

1930—Karl Landsteiner, Rockefeller Institute for Medical Research, New York City.

1933—Thomas H. Morgan, professor of biology, California Institute of Technology, Pasadena.

1934—joint award, George H. Whipple, dean, University of Rochester School of Medicine and Dentistry.
joint award, George R. Minot, professor, clinical medicine, Harvard Medical School.
joint award, William P. Murphy, instructor, clinical medicine, Harvard Medical School.

Literature:

1930—Sinclair Lewis, author, New York City.

Peace:

1906—Theodore Roosevelt, died 1919; President of the United States.

1912—Elihu Root, formerly Secretary of State, U. S. A.

1919—Woodrow Wilson, died 1924; President of the United States.

1925—joint award, Charles G. Dawes, Vice-President of the United States.

1929—Frank B. Kellogg, formerly Secretary of State, U. S. A.

1931—joint award, Jane Addams, Hull House, Chicago.
joint award, Nicholas Murray Butler, president of Columbia University.

In the stimulation of worth-while endeavor in five different fields, all of the greatest importance for the welfare of mankind, the efforts of Alfred Nobel are still active and promise to be an increasing influence far into the future.

SCIENCE SERVICE RADIO TALKS

PRESENTED OVER THE COLUMBIA BROADCASTING SYSTEM

HARNESSING SCIENTIFIC DISCOVERIES

By Dr. P. G. AGNEW
SECRETARY, AMERICAN STANDARDS ASSOCIATION

To most of us radio is the most startling triumph of the machine age—this thing that can carry the human voice to the ends of the earth—through silent space—and with the speed of light.

I am sure that it all seems to you, as it does to me, a never-ending miracle that people in far-off Australia, or that intrepid band of explorers with Admiral Byrd in the desolate region down near the South Pole, can hear the notes of an orchestra a fraction of a second sooner than the people in the rear of the concert hall itself. Just to think that each of my words is being carried to your radio set in the form of electric energy less in amount than you use in the flicker of an eyelash. Yet it is caught by your receiving set, greatly magnified, and then changed back into sound with a fidelity so great that from a few syllables you instantly recognize the speaker's voice—all in far less time than you take to wink your eye.

We are apt to think of radio as being built wholly on science that is new in the last few years. This is, however, not the case. Ninety-two years ago electromagnetic waves were transmitted over a distance of two hundred feet, and they were successfully detected even through the walls of buildings. This remarkable experiment was done by one of the great men of American science, Joseph Henry, who later became the first secretary of the Smithsonian Institution in Washington.

Henry did this famous experiment on the campus of Princeton University, years before the famous gold-rush of the Forty-Niners. In another one of his remarkable experiments, he was able to magnetize a needle by induction from a lightning stroke eight miles distant.

He of course did not call it radio—that is a word which had not yet been invented.

During the same period Michael Faraday, in England, carried out a long series of world-famous experiments. One of his results was to show that in ordinary electric circuits the power travels chiefly in the space surrounding the wires instead of within the wires themselves. This was before our civil war, and at the time when the ox-cart was an important means of transportation.

Sixty years ago one of the great minds of the nineteenth century, Maxwell, showed that electromagnetic energy travels through space in the form of waves, and he showed many of the properties of these waves. One of these was that they travel with the velocity of light—a velocity great enough to travel round the earth seven times in a single second. He showed that these waves would behave like light waves, and that light itself consists of very short electromagnetic waves. Maxwell discovered all this by mathematical theory, and his work, like Newton's discovery of the law of gravitation, constitutes one of the great triumphs of the human mind.

Maxwell's work waited many years to be verified by laboratory experiments by a young German scientist, Heinrich Hertz, by name. By 1888 Hertz had not

only proved Maxwell's theories to be right, but in doing so had been able, for the first time, to set up a radio sending station. At least that is what we would now call it, for he was able not only to send out the waves, but to control their frequency or wave length.

The following year Sir Oliver Lodge succeeded in setting up a radio receiving station. It was the forerunner of the radio set to which you are now listening, though to the eyes of most of us the two would have no resemblance to each other. Lodge was soon able to give a public demonstration and by 1897 had patented the use of "tuning coils," which were the forerunner of the dial on your own radio set which you use to select the station to which you are listening.

In all this earlier history we see how slowly the developments came. There were time-lags of forty and sixty and ninety years between the beginnings of the scientific principles underlying the radio art and its practical adaptation to everyday use. Yet we have seen that by 1900 things had begun to move faster, and since then they have moved very much faster indeed. This has been especially true during and since the war. This reduction of time-lag in getting science into use is a matter of great human interest and significance. I shall refer to it again.

On Christmas eve in 1906, Fessenden—a great pioneer who was in many ways ahead of his time—actually succeeded in broadcasting a program. The following year he was able, for the first time, to transmit the human voice across the Atlantic Ocean.

All these things were accomplished without the use of electron vacuum tubes which are now essential to both the sending station and the receiving set. These tubes also have a long history. The principle upon which they operate goes back to early work of Edison's half a century ago. In fact, for many years it was known as the Edison effect. The tubes depend for their action on the control of the motion of electrons—those inconceivably small particles of electricity of which the very atoms of matter are made up.

The radio tube was put into workable form by De Forest in 1907, and it was greatly improved by Langmuir just before the war. (It is interesting to note that De Forest was unable to sell his patent and let it lapse rather than pay $25.00 for its renewal.)

Great popular interest in "wireless telegraphy" was created by the use of the "S O S" at the time of the sinking of the Titanic in 1912 and in other great marine disasters.

Yet a far greater interest was to come with the advent of broadcasting, which made it possible for millions of people to have the truly thrilling experience of bringing human voices out of the air by merely twisting a dial.

Present-day broadcasting was started by Conrad on November 2, 1920, with the opening of station KDKA, the first broadcast being the election of President Harding.

From then on the response of the public to this dramatic new means of communication was unprecedentedly great and rapid. How great the response was is well shown by the quickness with which this new medium of communication came into use in political campaigns. The radio played a major part in the campaign for the presidency in 1924, when the conventions of the principal parties were broadcast. Who does not remember the oft-repeated question put by Senator Walsh, the chairman of the Democratic convention: "For what purpose does the gentleman arise?"

The imagination of the country was fired by this new medium, and radio quickly swept into popular favor the country over. By 1928 it had easily

become the principal battle ground in national political campaigns.

This great popular interest brought about extremely rapid developments in the radio art, both technically and commercially. Among these were such important steps as the loud-speaker—the self-contained set—complete electric operation, which did away with batteries—and single dial tuning. Scores of other improvements followed each other in remarkably quick succession.

It is doubtful if the speed with which these many developments came and were adapted into everyday use has ever been equaled in any other field. We have seen how these advances in the underlying sciences upon which radio is based, slow in the early stages marked by the discoveries of Henry, Faraday, Maxwell and other pioneers, have come with increasing rapidity down to the present time.

It would be interesting, if we had the time, to trace the advances in other sciences, the results of which have come into everyday use. We should see the same increasing rapidly in the growth of the science and in its everyday use.

The process of mercerizing cotton was discovered by Mercer ninety years ago, but nearly all the development, and its introduction into everyday use, has come within our own time.

It is only twenty years ago that vitamins were discovered—slightly more than a decade since the discovery of the sunshine vitamin—yet every intelligent school child to-day knows the meaning of vitamins, and every dietitian, every country doctor is prescribing them.

No longer ago than 1924 the city of Detroit found that thirty-six out of every hundred of its school children were afflicted with goiter. In the short space of seven years this was reduced from thirty-six to only two in a hundred. This was accomplished by the simple process of adding a minute amount of iodine to the table salt sold in the region. As a result thousands of the school children of Michigan, present and future, have been saved from feeble-mindedness.

Among the numerous fields in which discovery and use have come with increasing rapidity, especially during our own time, have been the electric light, the telephone, the airplane, the moving picture.

In fact, the speeding up of scientific and technical research and the parallel speeding up in the process of putting the results into practical use have largely come about within our own lives. It has come to such a stage that many of our more progressive industries do their scientific research to order, so that they may meet present and future needs. This also has come about almost entirely within a single generation.

One of the important ways by which scientific developments quickly find their way into use is through standardization. When well done, this means to find out the best way of making a thing or the best way of doing a job, and then systematically making the thing or doing the job that way. This generally means the use of the results of scientific research and it often means new researches. Standardization is a cooperative job. It is carried out by companies and by groups, such as trade associations, technical societies and government departments, and also on a national scale. The American Standards Association is the national clearing house for the standards movement.

As we have seen in the case of radio and in other fields, scientific developments have been coming with constantly increasing rapidity. Why is this? And is it or is it not to our advantage as human beings? Science is playing a constantly increasing part in our lives. This, I believe, is bound to continue and to do so with increasing rapidity. In the first place there are more and more

people working in science and in applying it to our everyday life. Then, too, as we have seen in radio, more and better means are continually becoming available to do the work. It is like having a modern machine shop available to do a job instead of attempting to do it with a monkey wrench and a screw driver, as in earlier days.

But I think the most important reason is the attitude of people toward science. It is immensely significant that they look upon scientific methods with increasing sympathy and understanding. This is true both of executives in industry and of people in all walks of life. All this means that the machine age is continuing to increase its sway. Some people look upon this with alarm. I do not. I am sure that most people who have thought about the matter deeply take the view that through science lies the road to better ways of living and to the "more abundant life" for all of us.

PAINTING THE HILLS GREEN

By B. Y. MORRISON

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In the literature of many peoples, the idea of green hills clad with forests or with pastures, but in any case luxuriant and verdant, has become almost a symbol of happiness and well-being; and, like many poetic symbols, contains much more of fact than the casual reader might believe. In lands where the hills are not green, what does one find? Either hills or mountains that stand in the stark nakedness of their rock formations or the sorrier sight of barren earth, washing away year by year until the rock skeleton is revealed. This latter process may be slow or swift, but in its progress what happens? Essentially a loss of soil and a dissipation of the natural water supplies of the country. All the richer surface soils are carried off in the floods that fill the water courses until the country is only a mass of fissures and ravines in the poorest soils that can support neither plant nor animal life, and the water that should be slowly available is lost almost immediately.

In many cases man has contributed largely to this condition by deforestation, overgrazing, lack of adequate fire protection or poor cultural practises, all of which, different as they are in themselves, have the same basic menace, the destruction of the richer surface soils in which most plant life exists. Erosion is not merely a recent development of intensified agriculture but a phenomenon as natural as rain or the change of seasons. Just as water seeks its own level, so also does land; but the leveling of land occurs so slowly that it is not apparent except in exaggerated cases. This erosion, continually taking place in nature without the interference of man, goes on so slowly that the rich top-soil so necessary to plant life in general is formed as rapidly as it is washed away, and the green covering of plant life remains in equilibrium.

When, however, man interferes with the surface of the land or with the vegetational cover, the process of erosion is thrown askew and the wearing away of the rich upper surface of the land proceeds at a rate far greater than its replacement. With the vegetational cover removed by overgrazing or cultivation, the soil is exposed to the driving action of the wind and the washing of water. Rivulets become torrents when the impeding vegetation is removed and the torrents rapidly eat away the rich top-

soil, leaving a barren under-stratum from which the hardiest of plants can obtain scant nourishment. It is the problem of this rapid erosion with which we are here concerned, for it takes a heavier annual toll from the farmer than the combined forces of many of our more spectacular insect pests and diseases, which are quickly recognized, while erosion does not seem harmful until it has gained such headway that the land is ruined.

No doubt all of you have seen pictures of the barren and sterile rolling landscape of northern China or heard of the disastrous floods of its rivers. These are directly attributable to erosion in its advanced stages, caused by the interference of man. The forests have been stripped from the hills; all land, even to the steepest slopes, has been cultivated and later abandoned when the top-soil had washed away. What is left? Barren land that will support almost nothing. Even now in this country we have had some foretaste of like conditions with the occasional flooding of rivers such as the Mississippi, the Ohio and the Missouri.

Fortunately, this rapid erosion can be prevented and, what is more important, the problem, though large, is nowhere near as stupendous as in a country as denuded as China. We believe that when the people are made fully aware of the dangers of rapid erosion and demonstrated the means of preventing it, sufficient cooperation will be forthcoming to save our natural heritage. Recently the Federal Government has begun, under its program of public works, the task of bringing before the public the seriousness of uncontrolled erosion. Large areas have been set aside in various parts of the country to demonstrate the means by which erosion can be prevented and the means by which the land already barren can be reclaimed. These areas have been chosen, not only because they are in themselves much in need of such help, but also because they are located in regions where erosion has done considerable damage.

Let us go into some of the causes of destructive soil erosion. In the West and Southwest overgrazing has been one of the most important factors. Live stock have been allowed to graze continuously over large areas of land without giving the vegetation an opportunity of renewing itself. The plants have died and the soil no longer supported by vegetation has been sluffed away by water and wind until millions of acres have become waste. This could have been prevented by judicious grazing. In many places our forested mountains have been denuded by over-lumbering. The remaining vegetation has become too scanty to hold back the water accumulated as snow during the winter. Instead of feeding a gradual supply of water to the lower arable valleys, the water rushes down in devastating torrents, strewing the valleys with rocky debris, eating away the soil and dissipating the water so rapidly that none is left for the dry season. Our farmers have in many cases tilled the soil of slopes so steep that the downward flow of mud is inevitable. Small depressions have been allowed to become ugly gullies ever increasing in size. The fine-grained friable soils of the semi-arid prairies have had their protective sod-covering removed for mile after mile with no attempt at strip-cropping, only to have the soil blown away by the strong desiccating winds of autumn. You all no doubt recall the dust-laden air which almost obscured the sun for several days last summer. This dust represented thousands of tons of good soil lost to the Middle West. These are only a few of the causes of excessive erosion.

The ultimate goal of all erosion control work is the establishment of a green mantle of vegetation over all surfaces of the land which, by their nature or slope, would rapidly erode should this protec-

tive covering be taken away. If the surface is at present well protected, we must see that it remains so. If the surface is already denuded and eroding, we must replace its vegetative covering as soon as possible, for the damage, once begun, spreads rapidly.

When one is faced with the problem of restoring vegetation to eroded lands to make the hills green again, what must he consider?

First, he must have a thorough knowledge of the soil conditions as they exist now, for these will limit the kind of plants to those that will survive under impoverished conditions. He must know the natural precipitation, as this will determine not only the nature but also the amount of plant life that may be expected and, finally, he must know the temperature ranges and the length of the growing season. He must study the surviving vegetation and the records of previous plant life, as they are most important, suggesting to the plantsman various other plants that usually accompany the species remaining.

Since any local flora represents the adaptation of plant life to natural soil and climatic conditions, this study will make clear the point beyond which it would be unreasonable to go. It will show which land should be returned to grass, which may be most wisely returned to forest and which must find some intermediate treatment. It will show also how much vegetation can be planned for, since plant populations are dense or sparse for very definite reasons.

In studying plants that are to be used for revegetation, the plants themselves must be carefully considered as to their structure and habit. Their roots must be considered: are they fibrous, widespreading and capable of penetration to some depth in search of food? How does the plant increase as it ages? Does it reseed itself abundantly and successfully or does it send out widely running stolons or shorter underground rhizomes? Does it bend down and root at the tips of its shoots, or does it, like a honeysuckle vine, scramble over the earth, rooting at every joint?

Again, one must know if the plant for proposed use has any other virtues than those related to the preservation of the surface soil. For the present we are concerned only with those features that relate to bird and animal life, whether in the actual production of forage for browsing, fruits and seeds for eating or mere shelter.

While it has been truly said, therefore, that any plant is a potential erosion control plant, it will be appreciated that in emergencies like our present time, the use of a rather limited choice of plants seems wise, with a very keen appreciation of the fact that each erosion study presents a particular problem that possibly may be solved once for all time or may require a continuing plan in which the first plantings will be made of the only plants possible under the existing conditions but which will make possible the later introduction of plants of greater value that could not have survived at first.

It is believed by many that the most suitable species to use in replanting an eroded area are those which grew there formerly and still are found in the neighboring region, for certainly what plant would be better fitted than one found growing in the same climate? So far, so good. But remember what has happened to the soil. It has changed completely. The sterile clay now exposed has little food for the plant. The water which once was absorbed and held for the plant now runs off. Erosion has changed the environment to stark desert conditions as far as the plant is concerned, and it can not regain a foothold. Much hardier kinds of plants must be the pioneers.

The question has been raised rather critically as to the necessity of foreign exploration for the introduction of

plants for such uses as this. Although no complete answer should be attempted at this time, there are many plants that may be cited as examples of successful introduction and naturalization, maintaining themselves and invading new territory until it is sometimes forgotten that they are not native to this country.

Among the familiar grasses that dominate parts of the country pastures, one might mention Kentucky Bluegrass, which is native to the Old World and yet carries an American name because of the success of its establishment here. Timothy, an English grass, introduced in 1720, is now one of our most widely spread pasture grasses. In recent years, perhaps the most conspicuous grass introductions have been the several crested wheat grasses from the Orient, all of which are so much more permanent than the American species of the same family that only they are being widely increased and seeded to furnish forage in land now removed from cereal cultivation.

None of these grasses are soil-binding grasses except as they cover the soil with vegetation. As an example of an introduced grass that binds soil by its spreading underground stems, mention might be made of Bermuda grass, a species so invasive as to become a weed near cultivated fields, but of greatest value in poorer soil, where it is needed only for its invasive and soil-binding qualities. Studies are now being made with various native grasses, particularly with several of the Gramma grasses and Paspalums that are known to be good forage and yet do not occur in nature in sufficient quantity to prove their ability to possess the earth.

Another introduced plant that is valuable for this work and yet a menace under too favorable conditions is the Japanese honeysuckle, which covers the ground, rooting at every joint and preventing any soil erosion while it builds up a humus layer. In too good soils and in too mild climates, its spread is too successful, so it must be held in check by planting on the poorest sites. So far, no native vine has come to our attention that approaches this Oriental plant, although various dewberries are useful for some areas.

Among the herbaceous plants that are being studied are the lespedezas, of which several Oriental species have lately had much publicity. The only feature to be stressed here is that we have many native species in this country, none of which has ever become an important forage plant.

Among the important shrubs of this country that have been used for poor soils and eroded areas are the sumachs, all of which endure the poverty-stricken conditions of the eroded areas, since they are tolerant of heat and cold, of drought and low soil fertility. Perhaps no introduced shrub can offer a conspicuous parallel, although in the Southwest a shrubby Pentzia from South Africa seems likely to become a widely established and valuable browse shrub for that country with little rainfall, high temperature and limited capacity for vegetation.

Among the trees chosen for revegetation, the one species that outnumbers all others so far is the black locust which has almost every character that an erosion plant should have—an elaborate and widely-spreading root system, a capacity for enduring poor and dry soils, and wide temperature ranges, and producing from its best forms a valuable timber.

These few examples serve to illustrate only the various types of material that the plantsman is growing for use in the erosion demonstrations now under Federal care. They represent essentially plants that will survive under particularly difficult conditions and will serve to reestablish the green cover that once was everywhere. In themselves they are

plants often of secondary value but of real value because they make safe the engineering work done on the sites and furnish a beginning for new plant populations. The problems of their production are many and varied and always there is the knowledge that there must be more seed and more seedlings than would be needed under favorable conditions; and hardier and tougher strains, for nature is no longer helpful when man attempts to make green again the hills from which the natural vegetation has been lost.

PSYCHOLOGICAL RESEARCH IN SOVIET RUSSIA[1]

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ALTHOUGH the Russian experiment may present a confused picture in certain political and economic ways the contribution to science, especially to psychology, is in many ways striking and original. To uproot 170 million people from their old habits and customs is indeed a vast psychological experiment in itself. It shows the wide margin of adaptability of human nature with the environmental setting. The psychological principle of substitution of one cultural trait for another has been put into effect on a large scale. For example, the excessive competition between individuals has given way to group competition and the conquest of nature and society. The profit motive has been outlawed and is considered a sin. The religious motive has been redirected from superstition, fear and "other worldliness" to a better society here and now. Simple peasants, supposedly stupid and lacking in mechanical ability, have become able scientists and engineers. One must look for the chief contributions to psychological research in the new social order and the new motivation.

As the rest of the world looks at the machine and certain aspects of science with concern, if not skepticism, the Russians believe these very forces will give them freedom. Science and the scientific method underlie their whole philosophy of life. In addition to the universities and technical schools, over 800 institutes have been established to investigate the basic problems in society and human behavior. Each institute is responsible to one of the commissariats which helps define their problems for research. This affords an intimate and workable relationship between science and government. The psychological research relates primarily to child study, learning and the conditioned reflex, aptitude and intelligence testing in industry, fatigue, collective or group psychology, prostitution and alcoholism. Necessity will always remain "the mother of invention," and so-called pure science may benefit anew by this enthusiasm for applied science in the building of socialism. Frequently it is the vastness of an experiment or its social nature which is of interest rather than the originality.

In the field of child study, for example, the Communist Party requires every factory or collective farm to have a crêche or kindergarten. There are over 6 million children in such schools. The number of teachers is inadequate,

[1] This article is based upon the author's observations in Soviet Russia during the summer of 1934.

but many are well trained in the new science of pedology or the "science of the growing organism"—a combination of psychology, medicine and education. The system is one of "moulding" rather than "unfolding" as regards their behavior in the group and as to what they think and believe. Thus in accord with Lenin's wishes the rigid ideology is imposed very early. Frequently a child knows more about Marxism and dialectical materialism than how to spell or write. The arts are widely taught, such as the theater, sculpturing, painting, and especially caricatures of capitalists, kulaks, popes and nazis—inspired by the new régime. Children are instructed about electricity, machinery and carpentry. After a group of children put a toy train together they receive a lecture on the value of collective activity. The nervous, shy or individualistic child receives special attention, and unusual abilities are encouraged. The energetic side of a child's behavior is studied by measuring the intensity of a hand movement on a bulb or recording device simultaneously with some other central tendency. These experiments reveal inner conflicts and tension. Criminals and delinquents have been studied by such methods. Elaborate physiological studies are being made to determine which toys and play activities are best, in terms of the expenditure of energy and training, for children at different ages.

The genetic development of speech and thought and the higher skills have been carefully analyzed in children. Luria and Vygotski compared young children with apes in the use of tools and in the solution of simple problems. In an experiment with 2,200 children they studied memory for words with and without the use of pictures. In 10- to 12-year-old gifted children there was a 60 per cent. increase in memorizing by using associated pictures, while the stupid ones profited little by the double stimulation. Intelligence tests are fairly widely used in the schools and factories. In one study the results showed quite naturally certain cultural influences, in that the children of more able parents and from better homes, such as in professional or other educated groups, rated higher than those of the workers. This finding was condemned by the Communist Party as petty bourgeoise and created considerable discussion!

At the Institute of Biological Medicine in Moscow, elaborate studies of mental and physical growth are being carried out on 700 pairs of identical and fraternal twins. The director, Professor Levit, received part of his training at the Rockefeller Institute in New York. The most dissimilar feature in identical twins is in the T wave of the electrocardiogram. Most of the other physiological comparisons show striking similarities. One group of twins was taught how to reproduce models by parts, while their identical twins reproduced them by wholes or with the use of imagery. Even ten months later the retest showed that those who learned with the aid of imagery were superior in reproducing models. In treating identical twins suffering from rickets—one with rays, the other without—an apparent initial improvement with the rays was later shown to be definitely harmful, especially in throwing off contagious diseases. In these ways definite controls for various kinds of training and treatment have been introduced. Studies of the inheritance of high blood pressure, diabetes and gastric ulcer have shown that these diseases may be caused by genes of poor "expressive" capacity yet dominant. For example, when relatives of patients with high blood pressure were placed in emotional situations their blood pressure on the average was raised more than in

a control group. Persons with such latent biological unfitness would therefore be placed in factory positions free from emotional strain or worry. This is preventive medicine and psychological insight of the first order. And obviously the inheritance factor has not been completely lost sight of in a society which believes fundamentally in the importance of the environment.

The movement initiated long ago by the philosopher, John Locke, that ideas are not innate but acquired has its modern culmination in the work of the distinguished physiologist Pavlov. His analysis of the learning process on the basis of conditioned reflexes and the dependence of behavior on environmental stimuli are basic in the Russian scheme of things. Pavlov, now 85 years of age, keeps a large group of research workers busy in his well-equipped new laboratory near Leningrad. In spite of his greater affection for the old order than for the new the impórtance of his work, in addition to a personal letter from Lenin, gives him complete freedom and adequate funds and dogs. At present he is interested in analyzing hypnosis, hysteria and the disturbance of equilibrium. He has four generations of dogs in which he is studying the inheritance of temperament (excitability and inhibition). He finds certain dogs (the same as people) are more susceptible to nervous breakdown than are others. By giving a dog food with the presentation of a circle and an electric shock with an ellipse it is possible to set up a definite positive and negative response to these stimuli. If the circle and ellipse are brought closer and closer together a point is finally reached where the dog can no longer distinguish between the two. The strain in discriminating becomes too great, and the dog has an artificial neurosis. Krasnogorski is studying nervous and difficult children by similar methods. Each week Pavlov goes to a medical clinic to analyze cases from real life on the basis of his theories. An attempt was made to reform chronic alcoholics by establishing a fear response to the taste and smell of alcohol by an accompanying electric shock. But the results were not very successful.

The human equation in industry has been especially difficult in a country being industrialized so rapidly. Misfits, inefficiency and lack of skill has been the greatest obstacle to overcome. Most young Communists want to be engineers because of the social pressure, and obviously many lack the ability. Since the state pays students to be educated there has been a strong motive for careful selection. Institutes of psychotechnics have been established to investigate such problems. Over 200 laboratories have been organized to test for special aptitudes and physical disabilities in pilots, conductors, miners and factory workers. Elaborate fatigue studies have been carried on with the aid of physiologists. Researches in job analysis and the metabolic cost of different kinds of factory work have been made. Special attention is given to the safeguarding of the health of the laborer. The physiologist Kahn, for example, spends part of the time in his laboratory in detailed analysis of nerve respiration and part of the time in the factory analyzing the relative efficiency in terms of oxygen consumption of differing ways of laying brick or building machinery.

In a society which fosters the subservience of the individual to the group and idealizes collectivism new social phenomena may be observable. Dominance or leadership in certain individuals is of special interest as well as group conformity and suggestibility. The traditional family unit has not been abolished but has given way in importance to the factory, community or farm collectives.

Human affections are just as real, but the home plays a different rôle with the state taking over many of its functions, as in the preparation of meals, education of children and recreational facilities. One consequence of the freedom of women is that mother "fixations" in the children are not so frequent. The mother has an emotional outlet through her work as well as through her children, which on the whole has been healthful for both. Students of social or cultural change would find innumerable problems to study in Soviet Russia.

With the nationality policy of the new régime and the self-determination of all minority racial and national groupings there has been an accentuation of certain differences in the use of native languages and customs. In certain isolated communities long-standing local antipathies and feuds have been eliminated. Primitive groups in Siberia and the Caucasus have been studied by ethnologists and psychologists. The more primitive groups have been given an alphabet and a literature—communistic in content, to be sure. Experiments are being tried, such as analyzing the content of the thought of backward people, educating them in advanced ways of life away from fear and superstitions or in getting gypsies to become farmers in one locality. The chief criticism of this policy relates to the extent of the freedom involved. The form of expression may be free, as in the use of dialects, and text-books really are printed in over 40 different languages. But the content must be proletarian, thus hampering some of the customs relating to the old order which may be of value.

The Soviet way with the criminal is deserving of attention because of the originality of the methods employed. Institutes have been established for the study of crime and delinquency. An attempt is made to eliminate the motives leading to anti-social behavior and to reeducate the one who errs. Thus crime is believed to be an environmental problem and can eventually be "liquidated" as soon as every one is properly fed and clothed. The words "criminal" and "prison" are no longer used. Labor communes in factories or on farms have been substituted for prison bars, and the prisoner must work in order to eat. The Soviets think crime has decreased, but reliable statistics comparing the old and new orders are difficult to obtain. In fact, a comparison would mean little because of the vast differences as to what is considered criminal now and then. Recidivism has decreased, for only 20 per cent. of the criminals relapse into their old habits. The most frequent offenses are stealing, inefficiency and sabotage. Four factors dominate in the new theory: (1) abolition of long sentences; (2) industrial reeducation; (3) as normal a sex and family life as possible, and (4) removal of the prison stigma and bullying by attendants. Recognizing that one of the strongest motives to reform relates to the family the prisoner is allowed to go home at regular intervals, and a single person may marry. Due to the control over the individual by the rigid political system, these schemes appear to work. Delinquency is still a problem, especially among the homeless children with "declassed" or exiled parents. The state has been successful in caring for them in certain cases.

In many respects the most interesting and possibly the most significant psychological research relates to the treatment of mental and emotional disorders. The emphasis is on prevention rather than cure and the treatment—social rather than individual. In the world at large there is some evidence of the increase of

the common neuroses with civilization. Personality frustration in modern life is related to such factors as economic insecurity and unemployment, false motives, fears and anxieties; sense of sin and superstition associated with religion and excessive guilt feelings with sex as well as "mother fixations." At a recent congress of psychiatrists in Kharkov there was general agreement that the common neuroses had declined with the elimination of the sources of conflict mentioned above. Dementia praecox, still the most frequent organic disorder, has decreased by treatment of early symptoms in the school and factory. Manic cases are placed on "shock brigades" in the factories to use up their excess energy and thereby prevent excessive depressions. The secret political police rounded up the prostitutes, who were subsequently taught a socially useful task and made to believe they were wanted, in fact, badly needed in the building of socialism. Prostitution has practically disappeared, and consequently syphilis and paresis have decreased. Wide-spread propaganda in the factories and schools has controlled the excessive use of alcohol and hence delirium tremens is less frequent. Hysteria among the women is not encountered so often now that they play a more active rôle in society. Suicide is rare among the young people, but that was true in the old days. New problems have arisen with the intense and feverish activity of the new order, such as excessive fatigue and exhaustion. No doubt certain fears and guilt feelings remain relative to the secret police and the Russian indifference to work. One would like to have controlled experiments and reliable statistics to verify these impressions—but the indirect evidence at times is quite convincing. The emphasis on preventive medicine and social prophylaxis is an important contribution.

The research in the psychological laboratories of the larger universities is fairly extensive, but on the whole the most significant work relates to the institutes and vast social experiments in the new society. The research may be quite spotty and naive and often it is poorly controlled and statistically unreliable. At times the experiments are mere repetition of studies initiated elsewhere, and occasionally political opinion and bias play a part. But this phenomenon is not peculiar to Soviet Russia in a nationalistic world where politics distorts scientific thought the same as superstition and fear did in former days. Many of the approaches are original and the findings significant. As the political and economic systems settle down, we may look for scientific contributions from a people who have proved their creativity often in the past.

THE FUR-BEARERS OF NEW YORK STATE

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As a boy, the writer was regaled with stories of the fur trade of Canada and the far north. His source of information, the "Book of Knowedge" and various geographies, lent the impression that a rigorous climate and arctic storms were a necessary factor in the priming of full, heavily furred pelts. College geography texts of to-day do nothing to allay these beliefs in the laity, and the colorful romance of the oldest industry is built on tales of suffering and hardships, that Dame Fashion may cater to her ever-increasing needs.

Recently, the residents of Louisiana were astounded when Arthur[1] asserted the catch of furs in this subtropical state per annum exceeded that of all the Canadian Provinces and territories and Alaska combined. Because of the enormous numbers of muskrats taken (3 to 6 million annually) it is quite conceivable.

But what of the status of New York as a fur producer? How does the state with the largest population compare with others throughout the breadth of the Union? How does the Empire State contrast with its neighbors to the north, the Canadian Provinces and Alaska?

Listing the value of the raw fur catch of the 1924–25 season for fourteen states and Alaska, Arthur places New York seventh with an estimated annual catch of $1,500,000. Louisiana, Michigan, Pennsylvania, Minnesota, Tennessee and Alaska had a greater value, according to this report.

The intent of this paper is to demonstrate that New York, in spite of its populous nature, ranks second only to Louisiana in the annual harvest of its raw fur crop.

It is extremely difficult to amass accurate figures on the fur catch. Conservation officials make little attempt to secure trustworthy data, and are given little or no help from the trapper. Twenty-six states now seek information on the annual numbers of the fur-bearers taken each year. A very few states license their fur buyers.

In 1919, New York made an initial attempt to secure data on the numbers of fish, game and fur-bearers taken. Figures were secured by the county clerks when the hunter applied for a new license. While such figures give some indication of a fluctuation in numbers taken as might occur from year to year, they are notoriously inaccurate. In 1928 only 37 per cent. of the licensees reported taking game, while the following year, from a total of 627,541 licenses issued, returns were made on a third. We thus have reports on the numbers of animals taken by only a third of the licensed hunters. It would thus seem justifiable to multiply the reported annual take of any one species by three.

There is another factor, however, that accounts for a huge swelling in the reported numbers of the fur-bearers taken. In New York a landowner is permitted to trap his own property without a license, and boys under sixteen are likewise not handicapped with the necessity of buying a license. The reader not acquainted with trapping conditions in the United States will scoff at the idea of any appreciable amount of fur being taken, in the aggregate, by boy trappers. Yet a very large percentage of the furs in this country, the total value of which

[1] *Louisiana Dept. Conservation Bulletin* 18. 1928.

HOME OF HUDSON SEAL

A MUSKRAT MARSH OF CENTRAL NEW YORK. FIVE MUSKRAT HOUSES SHOW IN THE PICTURE, WHILE THE TRACKS OF A WANDERING MINK BORDER THE SNOW NEXT TO THE WATER.

has been computed to be worth $60,000,000 annually to the trappers, is taken by boys in the rural schools. Even in the New York City schools there are boys at the present time who make a good profit from furs taken on the trap-line.

During the past eight years the writer has been engaged in making a study of the fur-bearers of New York and has amassed considerable data during the period. Not the least interesting is information on the number and value of the furs taken by minors. Eleven fur buyers, who bought, in the aggregate, 45,000 muskrats and 15,000 skunks, reported that 35 per cent. of these were trapped by boys under sixteen. One buyer states that 75 per cent. of his 2,500 skunk pelts were bought from young schoolboys.

The reader may object that the rarer, higher priced pelts are seldom trapped by boys. The important fur-bearers of New York are the muskrat, skunk, raccoon, mink, red fox and the weasel. The first two are, however, the important fur animals of the state, as they are throughout the nation. The muskrat is the pillar of the fur trade, having long since replaced the beaver. The muskrat and skunk, in New York, total in actual numbers taken ten times as many as all the other furbearers combined. A survey by the writer in 1931 of ten large fur buyers throughout New York state showed that skunks and muskrats totaled 142,000, while all the other species aggregated but 14,100. Furthermore, the value of skunk and muskrat comprise two thirds of all the money paid to the trapper in New York.

A few specific instances will dispel any suspicions the reader may enter-

tain regarding the numbers of furs taken by these precocious trappers. A fifteen-year-old boy trapped 100 muskrats, 21 skunks and 1 mink during a single season; another twelve-year-old took 14 skunks and 13 muskrats, while an eleven-year-old schoolboy trapped 8 'rats in a few weeks.

How does the world's largest city affect trapping conditions? As a fifteen-year-old boy, the writer trapped 30 muskrats at Flushing, eleven miles from Times Square, New York City. During the 1916–17 season two schoolboys took 300 muskrats and a mink at the same place. It seems incredible that two boys should harvest a crop of "Hudson seal" worth in excess of two hundred dollars, within sight of the New York City sky-line, but such was the case. Other fur-bearers still hold their own within a few miles of the world's greatest metropolis. The weasel and opossum are not uncommon, while a few foxes and skunks yet remain.

From the foregoing facts, we must conclude that a third of the skunks and muskrats are trapped by unlicensed boys in New York. This, indeed, is a conservative estimate.

The Conservation Commission lists a third of a million muskrats taken in 1928. Inasmuch as only 37 per cent. of the hunters reported taking game, we shall feel justified in doubling the number of muskrats. Add to this the number taken by unlicensed boys and we have nearly a million 'rats secured by trappers for this year.

The Board of Game Commissioners of Pennsylvania estimated that over a million muskrats were taken during the two seasons of 1927–28 and 1928–29. Because of a mountainous topography, much of Pennsylvania is unsuited to muskrats, while New York, on the other hand, has far more marshes, creeks, extensive lakes and vast swamps that swell the total population of the amphibious mammals. Is it small wonder that we should expect to find New York leading her nearest eastern rival by twice the number of muskrats taken?

The skunk is second in value as a fur-bearer, not alone in New York but throughout the Union. The 72,623 skunks listed by the Conservation Department for 1928 falls far short of Pennsylvania's 1928–29 record of 254,608. Surely the mephitine population of New York is not less than that of Pennsylvania. The reason for the apparent disparity in the annual catch of the two states lies in the methodical manner Pennsylvania employs to secure accurate figures relative to her annual take of fur. If an attempt is made to determine a reasonably accurate figure on the number of trapped skunks, as was done for the muskrat, we find over 200,000 are collected in this one year. As a matter of fact, the writer knows a fur buyer who collected 22,500 skunks in one season in western New York.

In determining the catch of fur-bear-

TABLE 1

FUR-BEARING ANIMALS TAKEN IN NEW YORK STATE DURING 1928

	Listed in Annual Report of N. Y. State Conserv. Dept. 1930	Estimated total number taken	Estimated value
Muskrat	347,113	991,170	$1,486,755
Skunk	72,623	207,500	415,000
Weasel	....	75,000	37,500
Raccoon	27,886	55,772	334,632
Red Fox	10,616	21,232	318,480
Mink	7,133	14,266	171,198
Gray Fox	2,269	4,538	8,976
Opossum	1,328	2,656	1,859
Otter	1,135	2,270	56,750
Marten	183	366	7,320
Fisher	66	122	7,320
Bear	98	98	980
Bobcat	109	218	436
Totals	**470,559**	**1,375,208**	**$2,847,206**

Photo by Dr. W. C. Muenscher

A WEEDY AREA IN AN ADIRONDACK RIVER

ARROW-HEAD AND PATCHES OF PICKEREL-WEED FURNISH FOOD FOR MUSKRATS AS WELL AS NESTING BLACK DUCKS.

ers other than muskrats and skunks in New York during 1928, we shall feel justified in doubling the numbers (excepting bear) listed by the state, as these latter figures represent but slightly more than a third of the licensed hunters' reports. Weasels are not even listed by the New York Conservation Department, but the probable catch each year in the state runs close to 75,000, according to earlier estimates of the writer.

Table 1, with estimates of the various species taken, is justified on the data already presented. It incorporates the numbers taken by unlicensed trappers and the huge number of licensed trappers who yearly neglect to file a return on their catch.

We thus have an estimated value on the New York State raw fur crop for 1928 of $2,847,206. Going a step further, we find a possible $6,501,363 fur crop for 1927, based partly on figures furnished by the Conservation Department (Annual Report, 1929, p. 238) and in part on the fur taken by unlicensed boy trappers and the many who make no report. We may regard the average prices for the pelts listed by the department as excessive (muskrats $2, skunk $2.50, mink, $17, etc.). Nevertheless, the catch may well have resulted in a five-million-dollar harvest to the trappers in this banner year of the fur trade.

If we compare these figures with Louisiana, we find that during the 1927–28 season, this southern state harvested a fur crop that brought the trappers $5,125,363. Thus New York compares remarkably well, at least in this year,

with Louisiana, which is generally accepted as the leader in fur production in the United States. Pennsylvania trappers, during the same season, took fur with an estimated value of $2,099,714.60. We need not concern ourselves with any other state, for, excepting Michigan, for which I have no figures, there is little or no comparison.

Turning to the Canadian Provinces, we find the Dominion Bureau of Statistics has gone to some trouble to secure accurate information on the value of the raw fur catch. The figures are based not alone on the reports of licensed fur traders, but combine annual statements, based on royalties, export tax, etc., to determine the approximate annual catch. The value[2] of wild caught fur-bearers from Canada, during the 1927–28 season, totaled $17,052,890. Thus New York produced in value of furs taken during the same period, a fourth as much as the entire Dominion during this period. Or in 1928–29, when the estimated value of wild caught fur-bearers in Canada amounted to $16,402,288, New York was harvesting a fur crop equal to a sixth of this. The vast province of Quebec, more than fourteen times the area of New York, produced considerably less, in numbers of animals taken and value received, than did the Empire State during the 1927–28 and the 1928–29 season. This does not mean, of course, that New York has more fur animals than Quebec. With probably ten times the number of trappers that the Canadian province produces, there is to be expected a considerably larger take of animals.

We have spoken of the quantity of fur taken in New York. Let us discuss briefly the quality. The finest muskrat pelts suitable for Hudson seal are taken in New York, especially from the central and western part of the state. The high quality of these pelts is reflected in the top prices paid for them. George I. Fox, New York fur merchant and head of one of the largest raw fur receiving houses in the world, writes to me that the average price for 1934 New York muskrats is $1.40, for Louisiana, $.65, while pelts from the central and western states bring $.80. He further states that New York muskrats are far superior to Canadian 'rats in size, color and quality.

The skunk, second in value only to the muskrat, is graded according to the amount of white in the fur. If the pelt has little white, it brings a good price. New York skunk will run 60 per cent. to No. 1's and 2's, those having little white, while these grades from Minnesota, Iowa and the Middle West will average less than 20 per cent.

Other furs from the Empire State are likewise graded as high-class pelts, bringing the value of the individual skins to the trapper considerably more than those taken in more southern latitudes.

Sufficient data have been presented to show that New York is a fur producer of the first rank. It is certainly the third, if not the second most important state in the Union as regards the value of fur-bearing animals. How may she best maintain this position? Present laws, while considerably improved over those of a decade ago, are not adequate to protect and perpetuate certain of the more valuable fur animals of the state. Some are in actual danger of extermination. The fox, a splendid game animal and fur producer, is given no protection. No closed season safeguards the fisher, highest-priced of New York furbearers, while the otter, with its prized, durable fur, is not given the benefit of any protection.

Personal correspondence and interviews with many buyers, most of whom

[2] Canada Yearbook, 1931.

have the interest of the fur animal at heart, tell the story of ever-decreasing yearly catches. It might be argued, particularly during the past few years, that this decrease is due to low prices paid for the pelts, which makes trapping unprofitable. The writer entertains serious doubts if the recent depression has safeguarded these animals. More are trapping to-day, if my observations are general, than did when prices soared skyward a few years back.

It is apparent to those who have investigated the situation that, with proper management, the suitable muskrat habitats can be made to produce three times the number of animals they now do. The extensive draining of swamps, too often unsuited to agricultural crops because of alkalinity or excessive acidity, has caused wide-spread decrease in the number of the animals during the past few years. The muskrat should be considered part of the agricultural crop on farms when conditions are favorable for the animal's natural increase. The value of the pelts that can be taken from an acre by sane trapping compare favorably with many farm products. A Buffalo man values his muskrat marsh at $35 per acre, and has cleared $5,100 in a single year from the sale of 'rat skins from this marsh.

Many of our fur-bearers have a value other than fur producers. The insectivorous habits of the skunk, the mouse-destroying proclivities of the fox and weasel and the sport of hunting furnished by the raccoon are in themselves sufficient reason for stringent laws that will protect these animals while the pelt is unprime.

Every state conservation department is now engaged in active propagation of fish and game birds to be turned free, either to replenish depleted areas with breeding stock or to furnish sport directly to the gunner or fisherman. Certainly we should provide for our fur animals, which furnish a sizable financial return along with the sport they produce. Little, if any, monies are turned back into the improvement of the fur resources of the states, yet the trapper pays an amount commensurate with that of the bird hunter or angler.

Certain reforms are immediately needed in the conservation of our fur-bearers. New York should grant a closed season to the fox and fisher during the period of their unprimeness the same as is now afforded the skunk, muskrat and raccoon. A qualified field agent should investigate needed changes in the various parts of the state, where certain species are in danger of extirpation. There are large areas in the state that are suitable only for fur production. The craze for extra agricultural land is over. Let a percentage of our extensive wild acreage return to its original state, which would mean more fur and game. Surely the state should give more thought to her fur-bearers, which, in normal years, pay interest, at 5 per cent., on a capitalization of $40,-000,000. Such an asset is certainly worthy of careful conservation and wise administration.

PRESIDENT KARL T. COMPTON

THE PROGRESS OF SCIENCE

DR. KARL TAYLOR COMPTON, PRESIDENT OF THE AMERICAN ASSOCIATION

Dr. Karl Taylor Compton, the new president of the American Association for the Advancement of Science, is one of America's most distinguished physicists. Born in 1887 in Wooster, Ohio, he is a son of Elias Compton, professor of philosophy and president of the College of Wooster. He spent his boyhood in the little Ohio town, attending the public schools there and doing his undergraduate work at the College of Wooster, from which he received a bachelor's degree in 1908.

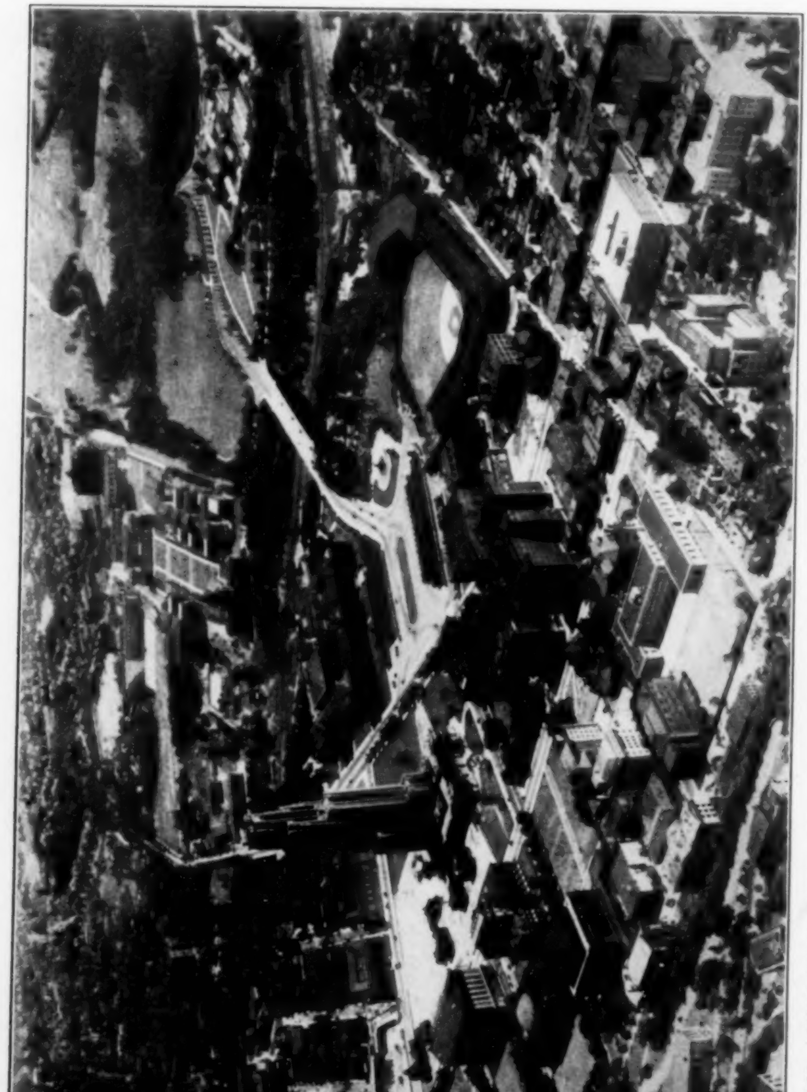
His first year of graduate work was also done at the College of Wooster, after which he went to Princeton University as a graduate student. His association with Princeton thus began at a time when the university was just beginning to be a center of scientific research in America. During the presidency of Woodrow Wilson, the university received large endowments for the development of the Graduate School and the Palmer Physical Laboratory was constructed. At that time Professor O. W. Richardson, the pioneer investigator of thermionics, was professor of physics at Princeton and doing much to stimulate electronic researches in Princeton's new physical laboratory. K. T. Compton, along with C. J. Davisson, who has just retired as vice-president for Section B of the American Association, became one of Richardson's ablest students. Thus it was that Compton early came under the influence of a great leader in research in modern electronic physics and received the training on which much of his later work is based.

After receiving his doctor's degree at Princeton in 1912, he spent two years on the faculty of Reed College in Portland, Oregon, before returning to Princeton as assistant professor in 1915. From then on he engaged in a program of researches which have contributed greatly to our understanding of the great variety of complex processes which occur in electrical discharges through gases. That work has a dual importance both for its bearing on fundamental problems of atomic structure and also because of the commercial importance of gas discharges as sources of light.

It will be recalled that this was the period in which the great "boom" in atomic physics started by the Bohr theory was just getting under way. Prior to that theory, empirical spectroscopists had found it possible to analyze spectra by introducing mysterious numbers called "terms" associated with the atoms. These numbers were such that the number of waves in unit length in the lines of the spectrum emitted by an atom could be expressed as differences between them. Bohr's theory provided the interpretation of the terms as being proportional to the actual energy content of the atom in various possible energy states and postulated that the emission of radiation took place when an electron in the atom jumped from one energy state to another. One way of testing this hypothesis was by a study of the process whereby atoms are excited on being struck by electrons having a known kinetic energy, the field of research known as the study of critical potentials. In this field, Compton's experiments were of the first importance and did much toward establishing firmly the physical reality of this essential hypothesis underlying the Bohr theory.

These researches were interrupted for a time during the war when Compton served as scientific attaché to the American Embassy in Paris.

After the war he was elevated to a full professorship at Princeton and there,



AN AIRPLANE VIEW OF THE ACADEMIC CENTER IN PITTSBURGH

SHOWING THE CATHEDRAL OF LEARNING A LITTLE TO THE LEFT OF CENTER WITH OTHER BUILDINGS OF THE UNIVERSITY OF PITTSBURGH IN THE FOREGROUND. THE BUILDINGS OF THE CARNEGIE INSTITUTE OF TECHNOLOGY ARE IN THE BACKGROUND. THE CARNEGIE INSTITUTE BUILDING, CONTAINING THE MUSIC HALL AND THE MUSEUM, LIES BETWEEN THEM AND THE CATHEDRAL.

under his stimulating guidance, there was gradually assembled a large group of experimental research workers engaged in the study of a great variety of problems in fundamental atomic physics and in the processes involved in gas discharges. Some years later he was appointed to the newly founded Cyrus Fogg Brackett professorship of physics, which permitted him to devote his full energies to the development of the graduate work in physics. During this period his original work and his enthusiastic efforts for the development of scientific research in America resulted in his being generally recognized as a leader of American physics. From 1927–29 he served as president of the American Physical Society. During this period he was also associated in an important capacity with the work of the National Research Council and the National Academy of Sciences.

While contributing much to pure science by his researches, he always had a keen interest in the fundamental scientific problems of technology. Therefore it was only natural that the Massachusetts Institute of Technology, faced with the need of filling the presidency, should turn to Dr. Compton. In the spring of 1930 he was persuaded to accept the presidency and thus the Princeton period was brought to a close. This selection may well mark a turning point in the development of technical education in America. American engineers have always been intensely practical fellows. The technical schools, accordingly, have given students plenty of training in shop and testing room, but have been regrettably laggard in giving sound training in the most modern and advanced phases of physics. Such a plan of study may have been appropriate for an earlier period in technology, but nowadays there are so many great industries which are directly founded on the results of modern physics that it is evident that a first-rate technical education must include a thorough grounding in basic pure science. Realization of this fact undoubtedly was the guiding idea in the minds of the men responsible for urging Compton to go to Cambridge.

In the four years which he has served as head of "M. I. T.," great changes in the institute have been effected in the direction of strengthening the work in fundamental science. A noteworthy feature of this growth has been its close integration with the technological studies at the institute. These developments will undoubtedly lead to a new and higher conception of technical education in America. That so much has been accomplished in these four years is, of course, all the more remarkable in view of the severe economic conditions of the time.

At the beginning of the present administration, Dr. Compton was selected by President Roosevelt as chairman of his Scientific Advisory Council, charged with working out a scientific program for the "New Deal." The council's first major accomplishment has been the development of a program for modernization and development of the nation's meteorological service, a plan which calls for adoption in practise of the new methods in meteorology which have been so successfully developed in Norway by Professor V. Bjerknes. The council is also hard at work on the details of a coordinated plan for the support of fundamental research in connection with the extensive public works program of the government.

In conclusion, let no one think of an antithesis between scientific research and administrative activity in connection with K. T. Compton. In spite of his great activity as administrator, Compton keeps in close personal touch with the work of the physics laboratory and finds time to supervise his own program of experimental work in spectroscopy in the M. I. T. research laboratories.

EDW. U. CONDON
DEPARTMENT OF PHYSICS
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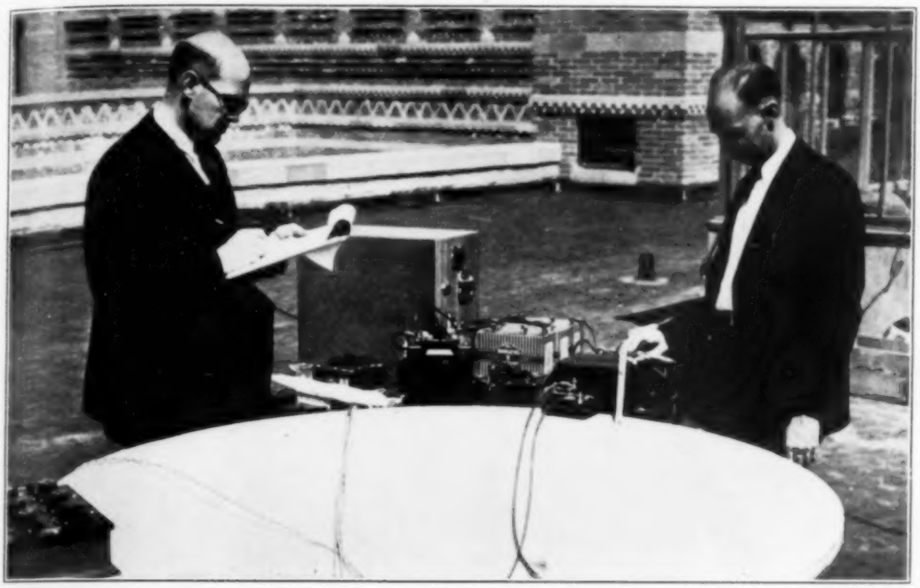
THE AMERICAN ASSOCIATION AT PITTSBURGH

The winter meeting of the American Association for the Advancement of Science was held in Pittsburgh from December 27 through January 1. Many of the sections and affiliated societies presented programs of great interest and importance. A few of those that may be mentioned were: the symposium on "Heavy Hydrogen and its Compounds," given before the sections of physics and chemistry; the symposium of the American Society of Naturalists on "Cytogenetic Evolutionary Processes and their Bearing on Evolution Theory"; Monday afternoon's discussion before the section of social and economic sciences on "Contemporary Economic and Social Problems under the New Deal" at which two assistant secretaries from the New Deal found themselves pitted against a Harvard professor in animated argument; and the same section's Tuesday evening program on "Economic Planning."

The general sessions of the association, held in the evening at the Carnegie Music Hall, presented Dr. William Alanson White, superintendent of St. Elizabeth's Hospital in Washington; the Sigma Xi Lecture by Professor E. A. Hooton of Harvard; the address of the retiring vice-president of the engineering section, Charles F. Kettering, of the General Motors Corporation; and the address of the retiring president of the association, Professor Henry N. Russell, of Princeton, who spoke on "The Atmospheres of the Planets." The eleventh annual Josiah Willard Gibbs Lecture, presented under the auspices of the American Mathematical Society, was delivered by Professor Albert Einstein, of the Institute for Advanced Study. Because of the strict limitation which was of necessity placed upon the number who could attend, this session produced much local comment. The lecture was the presentation of a highly technical subject, despite its title of "An Elementary Proof of the Theorem Concerning the Equivalence of Mass and En-

PROFESSOR ALBERT EINSTEIN IN PITTSBURGH

DELIVERING THE ELEVENTH JOSIAH WILLARD GIBBS LECTURE UNDER THE AUSPICES OF THE AMERICAN MATHEMATICAL SOCIETY.



PROFESSOR VERN O. KNUDSEN

WHO WAS AWARDED THE ASSOCIATION PRIZE AND L. P. DELSASSO (RIGHT) WITH THEIR APPARATUS FOR THE STUDY OF SOUND. BOTH ARE MEMBERS OF THE DEPARTMENT OF PHYSICS OF THE UNIVERSITY OF CALIFORNIA AT LOS ANGELES.

ergy," by the outstanding authority in that field.

The association's prize of $1,000 was awarded to Professor Vern Oliver Knudsen, of the University of California at Los Angeles, for his paper on "The Absorption of Sound in Gases" delivered at the joint session of the American Physical Society with the Acoustical Society of America. The paper is of importance because of its theoretical implications with regard to energy states of the molecule, as well as on account of its application in the field of practical acoustics.

The council of the association elected as president Dr. Karl T. Compton, president of the Massachusetts Institute of Technology. It elected Otis W. Caldwell, of Teachers College, Columbia University, general secretary, to replace Professor Burton E. Livingston, whose resignation was accepted with great regret. Dr. Earl B. McKinley, dean of the George Washington University Medical School, was elected to fill the unexpired term of President Compton on the executive committee.

The scientific and commercial exhibits of the association were well attended, not only by members but by the general public as well. Indeed, the public began its examination of the exhibits on the day before the sessions began and increased in number until, on Sunday afternoon, the exhibition halls came close to congealing and visitors could be admitted only when others left. Thousands, discouraged by the long wait for admittance, were unable to wait and many hundreds had to be turned away.

It is unfortunate that these meetings should partake so essentially of the character of a twenty-ring circus. Affording, as they do, the only opportunities for investigators in widely different fields to commingle, the crowded nature of the programs almost requires that one

attend only his own section meetings. Under these conditions, the reception, the biologists' smoker, the smoker for mathematicians, physicists, chemists and engineers and the section or society dinners assume added importance. Events of this nature to which your correspondent could go were very well attended and very much worthwhile.

The president, Dr. Edward L. Thorndike, the distinguished psychologist of Columbia University, presided over one of the most successful gatherings in the history of the association. Nearly 3,000 scientific men and women officially registered for the sessions; the active attendance was over 4,000. The director of exhibits reports that more than 20,000 people visited the research and commercial exhibition in the basement of the new Mellon Institute building.

H. D.

AWARD OF THE NOBEL PRIZE FOR THE TREATMENT OF ANEMIA

The award of the Nobel Prize in medicine and physiology jointly to Drs. George Richards Minot and William Parry Murphy, of Boston, and to Dr. George Hoyt Whipple, of Rochester, New York, for their discoveries in the treatment of anemia symbolizes the high regard in which their contributions are held by the medical world. It may be truly said that the great advances of the past decade in the understanding of disorders of blood formation have been made either by these men or as a direct result of their work. Begun in the laboratory as an experimental study of pigment metabolism, the unforeseen result has been the successful treatment of a hitherto fatal disease in man.

Dr. Whipple, formerly director of the George Williams Hooper Foundation for Medical Research of the University of California, became in 1921 dean and professor of pathology of the University of Rochester Medical School. Almost twenty years ago he began a series of carefully planned observations in animals upon the mechanism of the production of hemoglobin and its relations to biliary pigments. A technique once perfected, there issued from his laboratories a series of publications which have placed upon a secure quantitative basis the vague belief of former generations that the quality of the blood depended upon the quality of the diet. He and his associates proceeded with beautifully executed experiments to accumulate information, especially upon the amounts of hemoglobin which could be formed in a given period of time by a variety of food substances. The properties of fats, fish, vegetables, cereals, fruits, meat and liver were investigated in this respect. By 1922 cooked beef muscle, heart and liver were recognized as especially favorable for the regeneration of red blood cells and hemoglobin in dogs rendered anemic by repeated bleeding.

Characteristic of Dr. Whipple himself are the outstanding features of his work: the direct approach to the theoretical problem that interested him, the persistence of the attack and the conservatism of the conclusions drawn only after prolonged experimentation. Imagination there is, but disciplined by a profound respect for the verifiable fact. Thus, he suggested that pernicious anemia might be a disease in which there was a scarcity of material necessary for the construction of the stroma of the red blood cells. Nevertheless, he cautioned others against the hasty assumption that the results of his experiments in animals could be directly applied to the problems of anemia in man.

Dr. Minot was appointed in 1928 professor of medicine at Harvard and since then has also been director of the Thorndike Memorial Laboratory of the Boston

PRESENTATION OF THE NOBEL PRIZES

KING GUSTAF OF SWEDEN PRESENTING THE NOBEL PRIZE IN MEDICINE AND PHYSIOLOGY. PROFESSOR GEORGE H. WHIPPLE, WHOSE PORTRAIT WAS PRINTED IN THE SCIENTIFIC MONTHLY FOR DECEMBER, IS PARTLY HIDDEN BY DR. WILLIAM P. MURPHY, WHO IS RECEIVING THE AWARD. DR. GEORGE R. MINOT IS IN THE FOREGROUND ON THE RIGHT.

City Hospital. Since graduation from the Harvard Medical School in 1912, he has pursued an interest in diseases of the blood. The acquaintance with the subject gained in teaching and research became a rare intimacy in the practise of medicine. As time passed, he accumulated by piecing together fragmentary impressions and observations, as is often necessary in clinical medicine, a belief that dietary deficiency was in some way related to the cause of pernicious anemia. After numerous unsuccessful attempts at treatment of the disease with various types of diet, he beheld, in a few private patients given small amounts of liver in the diet, the faint light preceding the full dawn of discovery. It is significant that other clinicians fed liver to patients at about the same time without noting anything unusual as a result. Based on his profound clinical knowledge of the disease, his conviction that dietary inadequacy was at its root, and undoubtedly influenced by the implications of the studies of Whipple, he persisted. He and Dr. Murphy observed that a diet containing considerable amounts of liver was regularly beneficial to patients with pernicious anemia. Together they announced in 1926 the results of their successful treatment of 45 patients, most of whom by that time would otherwise have been dead. This work and their subsequent development of extracts of liver, which have made the method of treatment eminently practical, have been stamped with attention to quantitative detail. In addition to its intrinsic merit, it is an example of the possibility and value of quantitative observation in the clinic, forming a fitting counterpart to the experiments of Whipple in the laboratory.

Dr. Minot's contribution is again characteristic of the man. An observer less able to carry in mind a variety of clinical details would have failed to recognize the essential problem in pernicious anemia. His enthusiasm for investigation caused him to persist with diet therapy in the face of what was to others obvious failure. To him the slightest improvement was never spontaneous but the result of causes obscure, but nevertheless not too difficult or too unimportant to search for. Dr. Murphy, who since 1928 has been instructor in medicine at the Harvard Medical School and associate in medicine at the Peter Bent Brigham Hospital, possessed the calm judgment and untiring energy indispensable to a complete demonstration of their discovery.

Not only has the value of the contributions of these men already been realized, but also great will be the effect of their discoveries upon the medicine of the future. Even now in the light of these events much has been learned concerning the causation of pernicious anemia and its relatives close and distant in the family of diseases. In the field of alimentary tract diseases and in disorders of the nervous system, new points of view have been developed. It is unnecessary to enumerate the many honors which have come to these men, since there is no greater achievement in science than to have laid a firm foundation upon which others may confidently build a structure of new knowledge.

W. B. Castle

Department of Medicine
Harvard Medical School

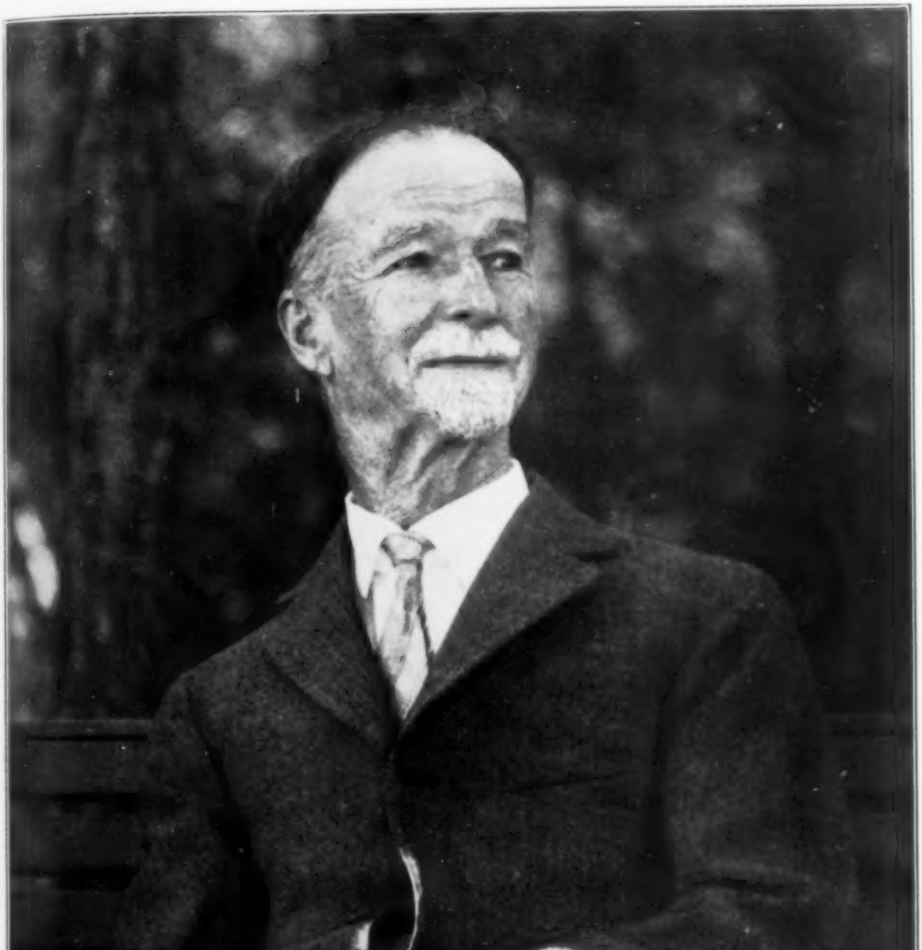
THEOBALD SMITH, 1859–1934

The death of Dr. Theobald Smith on December 10, in his seventy-sixth year, was an irreparable loss to medical science. He was distinguished for his work on the comparative etiology, pathology and immunology of infectious and parasitic diseases. At the time of his death he was president of the board of scientific directors and member emeritus of the Rockefeller Institute for Medical Research.

After his graduation from Cornell University Dr. Smith obtained his medical degree from the Albany Medical School. He had been chief of the Division of Pathology of the U. S. Bureau of Animal Industry for a number of years as well as professor of bacteriology at George Washington University when in 1895 he was called to Harvard to fill a chair in applied zoology; the following year he was appointed professor of comparative pathology. In 1914 he accepted a call from the Rockefeller Institute for Medical Research to fill the directorship of the Department of Animal Pathology at Princeton, New Jersey, a position in which he was active until 1929.

While he was in charge of investigating infectious animal diseases for the Bureau of Animal Industry, Dr. Smith demonstrated that ticks were the means of the transmission of Texas cattle fever. The results of this investigation were important, as it was the first proof that insect hosts are the essential intermediate agencies in the spread of some infectious diseases of great importance to man.

Probably his next best-known work is the differentiation of bovine from human tubercle bacilli. Hitherto the differing types of disease caused by these organisms had not been recognized. Koch, the original discoverer of the tubercle bacillus, at once realized the significance of Dr. Smith's work which has played a far-reaching part in the control of tuberculosis.



THEOBALD SMITH

A PHOTOGRAPH TAKEN ON HIS SEVENTY-FIFTH BIRTHDAY BY DR. CARL TENBROECK.

The investigation of blackhead, a fatal disease of turkeys, occupied much of Dr. Smith's time, and he was able to show that the condition was caused by the interaction of a nematode worm and a protozoan parasite. No such association of organisms as a cause of disease had been recognized previously and its significance for human and animal pathology can not yet be fully appraised.

Dr. Smith demonstrated that colostrum, the thin fluid that new-born animals suck from their mothers before the breast yields milk, has notable antibacterial and protective action. It was shown that when colostrum was withheld from new-born calves a large majority died from wide-spread infection with bacteria that are ordinarily harmless. Limitations of space make it possible to mention only three other discoveries made by Dr. Smith. As far back as 1894 he experimentally induced scurvy in guinea-pigs; he first demonstrated that killed cultures of bacteria may produce immunity; he discovered the immunizing action of balanced or neutral mixtures of diphtheria toxin-antitoxin in guinea-pigs and suggested their use for the prophylaxis and treatment of diphtheria.

Dr. Smith was the recipient of many honors from institutions in this country and abroad. Among those that conferred on him honorary degrees were Princeton University, Harvard University, the University of Chicago and the Universities of Edinburgh and Breslau; he was a member of the National Academy of Sciences and of scientific societies in many countries. In 1933 the Royal Society of London honored him with its Copley Medal.

In speaking of the personal qualities of Theobald Smith in the eulogy that he gave at the funeral service in Princeton, Dr. Charles R. Stockard said:

> Dr. Theobald Smith began his scientific life, and continued it, as a simple unassuming student of nature. He was in the highest sense a naturalist. He was devoted to simple understanding and constructive thinking. Complexities and uncertainties were realities to him, but his mind made no attempt to encompass complexities. The direction of his thought was toward finding some means of reduction to elementary simplicity.
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> He was clear-minded, strict-minded and absolutely honest. He was tolerant where tolerance is a virtue, but was emphatically intolerant of any compromise with error. He avoided every semblance of deceit, he was unpretentious and was most careful not to deceive himself. While in a world of cloudy and confused thinking with bungling attempts at the solution of pressing problems it is a joy and inspiration to have known a mind of such direction and clearness as that of Theobald Smith.
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> Dr. Smith's genius displayed to a high degree the rare quality of foresight. He visualized the line of attack on a broad problem as the master artist in his imagination sees the finished creation before it is begun. He carefully proceeded along the line of his interest step by step with a seeing eye and a penetrating appreciation of the meaning in what he saw. To him the greatest reward was the solution of the problem and toward this his efforts were ever turned.

C. W.